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ABSTRACT

The next 10 years provide an opportunity for the European Union (EU) to renew the science and technology (S&T) base and build necessary knowledge-society capacities and capabilities in Pre-Accession Countries (PACs). Applied research has faced a major downsize; redressing the balance in the research and development systems is urgently needed. Stated research priorities in national policy frameworks in PACS indicates a mirroring of priorities found across EU member states. The central challenge concerns ways in which S&T demand and supply are balanced. Research suggests PACs have the potential to sustain high-level research systems. Upgrading and updating applied research capacity and connecting it to the industrial demand side are urgent priorities; developments reveal promising trends that could provide a starting point. Direct technology transfer is limited and impacts survival of companies dependent on the speed of change in their productivity and competitiveness. A brain drain has led PACs to devote attention to attracting youth into research careers. Aspects of the process of building human capital and learning capabilities are to meet present skills gaps in the labor market; guarantee medium-term capacity of the S&T training system to deliver technical specialists, researchers, and teachers; and ensure longer-term sustainability of society and economic growth by opening good-quality education to all citizens. (Appendixes include an 89-item bibliography, S&T priorities, and S&T framework and priorities in PACs.) (YLB)

Enlargement Futures Project

Expert Panel on Technology, Knowledge and Learning

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The 'Enlargement Futures' project

In the next ten years the European Union (EU) enlargement process will move beyond its present focus on negotiations for accession with the candidate countries and will increase the interest in the challenges and opportunities to be faced by an EU consisting of 25-30 member states.

The 'Futures' project completed in 2000 by the Institute for Prospective Technological Studies (IPTS) outlined some basic issues related to the contemporary development in pre-accession countries (PACs) and their impact on Europe. However, this was only a first attempt to sketch the issue in the wider context of the development of the EU.

The need to better understand the uncertainties and challenges of the Enlargement process was recognised at a high-level meeting in Tallinn (September 2000)[1]. As a follow-up at a Steering Group meeting in Brussels (February 2001) a new foresight activity on the techno-economic and social impact of enlargement was launched – the 'Enlargement Futures' project – matching both the format of the 'Futures' project and its policy relevance.

The 'Enlargement Futures' project examines the main contemporary technological, economic, political and social drivers in the candidate countries and their possible impact on technology/science, competitiveness and employment in the enlarged Union with a time horizon of ten years. In order to achieve its objectives the project involves experts from PACs and EU countries in an interactive process based on workshops and seminars and supported by background research. The project is structured around four clusters of issues and challenges for the development of PACs and their corresponding thematic panels:

- Economic transformation
- Technology, knowledge and learning
- Employment and societal change
- Sustainability, environment and natural resources

[1] see meeting notes of 'Prospective Dialogue on EU-Enlargement: Science, Technology and Society', Tallinn/Estonia, September 13/14, 2000, http://www.jrc.es/projects/enlargement/

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Executive Summary

Introduction

The coming ten years will provide a period of possibly unparalleled opportunity for renewal of the science and technology (S&T) base and the building of necessary knowledge-society capacities and capabilities in the Pre-Accession Countries (PACs). The drive towards restructuring and modernisation of innovation systems at the national level and towards changing the learning environment in candidate countries is taking place at the same time as the development of European S&T and education shifts gear, with the launch of the European Research Area (ERA) and the e-Learning initiative respectively. The possibilities for synergies and an opening up of national systems provides a one-off chance for the PACs to find a fast track towards full integration in the European research and knowledge system.

However, turning opportunities into reality presents great challenges. In this paper we try to outline some of the central areas for action today in order that PACs will be able to become integral players in tomorrow's European knowledge-based society. It is important to note that these actions are aimed not just at the PACs governments and people, but call for a concerted effort from EU15 member states and industry in order to achieve an effective modernisation process.

Science and technology strategies

Many PACs particularly the Central and Eastern European Countries (CEECs) have a **long tradition of high quality fundamental science** and historically prestigious research institutions. The period of transition has eroded the stability that S&T needs in order to flourish, and there has been a squeeze on existing institutions and considerable strains to adapt. Despite these strains, the greater openness of national research systems is leading to their (re-) integration into the international science base.

Other pre-accession countries, such as Malta, Turkey and Cyprus may have not experienced the structural shocks of transition, but are nevertheless faced with serious challenges to carve out a position in the European Research Area and indeed the Global S&T system.

Whilst fundamental science has held up quite well over the past decade, applied research in CEECs has faced a major downsize. This has accompanied the collapse of industrial research activity and the privatisation of public enterprises. In general, there is an **urgent need to redress the balance** in the research and development (R&D) systems and to increase or further adapt applied research to serve the needs of a technologically advanced economy.

For all PACs the next few years will be ones in which it will be necessary to pursue a strategic pathway to **(re-) establish critical competencies and capacities in the key areas chosen**. It is necessary to be selective regarding the areas in which excellence is sought; to decide in which areas the search for excellence is a plain necessity, in which areas a low profile should be maintained and from which research areas the countries should withdraw altogether. These considerations form part of a strategy of specialisation on the basis of international synergies as well as competitiveness. They invoke tough choices for all countries, not just for PACs. This is of course a central theme of the policy framework of ERA. Today even the wealthiest economies can no longer pursue a fully comprehensive range of S&T options to the highest level – priorities have to be set.

A closer look at the stated research priorities in published national policy frameworks in PACs indicates a **mirroring of priorities that are found across EU Member States and at European level in the Framework Programme**. Most national programmes reveal a strong continuation of supply-side driven priorities (i.e. scientific and technological opportunity and interests) including emergent 'hot themes' such as biotechnology, nanotechnology, advanced materials and strategic necessities like information and communication technologies (ICTs). It would be appropriate to investigate the **relationship between the priorities selected and the research that is really needed** in PACs. Perhaps some research areas are earmarked more as a matter of national pride because they are cutting edge areas. Meanwhile, many national S&T plans also do include issue-driven priorities although it is often not clear how they are established. The issues are often country-specific and include ageing population, knowledge-society technologies, specific environmental protection demands (coastal margins, natural resources and renewables), cultural identity, linguistic and heritage factors.

In particular, we have not been able to **relate levels of investments in research competencies to the identified priorities**. There is no clear relation between priorities and resources that might send signals about how priority planning affects budget allocation. For example, given severely limited resources, it might be that the need to align S&T efforts to external funding (such as the EU Framework Programmes) may mean that research efforts are diverted away from domestic strategic capacities and needs.

The central challenge therefore relates to the overall system of S&T governance, and concerns the **ways in which the demand and supply of S&T are balanced.** On the one hand, a stable and high-level support for fundamental science is needed in order to develop a self-sustaining S&T system. But, not all areas can be supported. The choice of what to support should be driven by analysis of existing and potential excellence and its relations to specific demands of the country and its regions. Such decision-making requires the support of detailed benchmarking of existing performance, and an open process involving all stakeholders in a debate on the identification and setting of priorities. It also requires the **development of a long-term and strategic view of S&T as part of national positioning in its wider context**, and one which differentiates between the challenges faced at local, regional and international level.

So far, **only a few PACs have moved towards such transparency in S&T governance** and only in a partial way covering some constituencies (i.e. based on the efforts of one ministry or a sectoral theme). Efforts such as the foresight exercises in Hungary, Poland, the Czech Republic and Malta may provide a model for a way forward. But there is still a long way to go to achieve wide acceptance of these more open systems of governance.

PACs are facing the **challenge to move from rhetoric to reality in S&T policy**. New mechanisms are needed to implement S&T plans and to allocate the limited financial resources to research really needed by the industry and the society. This implies, among other things, transparent, open and competitive procedures and criteria. Systematic evaluation of research results and the socio-economic impact of policy measures will also be an important tool of S&T strategy aimed at quality and excellence of research and its utilisation by industry and society.

Knowledge institutions and capacities

An essential prerequisite to proper S&T governance is to establish a clear picture of the supply and demand of S&T and the functioning of the whole research, development and innovation (RDI) system. This picture is made up first of the research competencies that constitute the institutional base of a knowledge economy and the interactions for research, education and innovation. Secondly, there is the demand side and the industrial capacity to absorb new knowledge and technology. Thirdly, and equally important, there are the people that do research – the human resources that give life and motion to the knowledge society.

In recent years PACs have been following different development tracks and as a result many of the R&D institutions left today are self-governing and autonomous, signalling that greater openness has been achieved. Recent data giving an aggregate comparison between some PACs and current EU members paint a positive picture, suggesting that the PACs have the **potential to sustain high-level research systems**, at least on a par with several current EU Member States. However, while such data certainly do give grounds for hope, it would be premature to assume that the work of reconstructing the knowledge infrastructure has mostly been done.

The main problems relate now in all PACs to the **fragmentation of the RDI system**, based on the lack of interaction between the main actors, and thus its insufficient efficiency. The history of central planning in CEECs and the reliance on public funding sources have inhibited the growth of business-research linkages, and this contributes to the difficulties that public research institutes face today. Branch research institutes meanwhile have severe difficulties to retain professional equipment and their best staff.

Problems of data collection leave us uncertain **whether the quality and relevance of the S&T base is suited to the needs of a knowledge economy**, but certainly the lack of scale and fragmentation of the institutions is a problem. Upgrading and updating the applied research capacity and connecting it to the industrial demand side are therefore urgent priorities for most candidate countries. There is no set pattern for achieving this upgrading in all PACs. But present developments reveal three important and promising trends that could provide a starting point: **1) the strengthening of research teams at universities, 2) the emergence of self-standing centres of excellence, and 3) the growing participation of PAC research teams in multinational research projects.**

It is often claimed that there is a **lack of industrial demand for the services that research institutes can offer**. However, competition is driving domestic industry to innovate and apply new technologies, to develop new products or upgrade their quality to meet the requirements of the customers or gain new market positions. Thus, some enterprises are starting to collaborate with universities or to buy-in the services of individual researchers on a part-time basis. Some others are building up in-house research capacity or turning to emerging players that offer knowledge-intensive services.

The survival of the companies has been highly dependent on the speed of change in their productivity and competitiveness and thus the **ability for fast acquisition and application of new technologies**. Presently, the main mechanisms for technology transfer in candidate countries are mostly indirect such as:

- The inward transfer of 'hard' (product, process) or 'soft' (management) technology, mainly by foreign direct investment (FDI);
- The integration of local firms into the international production chain by subcontracting, outsourced assembly processes, provision of distribution services, reverse engineering of products and/or customised production and design;
- Forging co-operative industrial alliances with foreign partners and learning-by-trading.

Direct technology transfer is limited to interchange of personnel (spin-offs from research units or researcher-led start-ups) and is rather small scale.

While foreign direct investment is considered a key vehicle for technology transfer in PACs, it is supported by changes in large domestic enterprises, which have often followed a pattern of privatisation and subsequent conversion into subsidiaries or specialised suppliers to multinational corporations. This internationalisation of ownership however rarely results in demands on local fundamental research capabilities. However, the **need to adapt technology to local circumstances has been facilitated by the availability of knowledgeable individuals**. In addition there are some important examples, where a highly qualified research workforce has attracted foreign investors to exploit domestic research capacity, e.g. Nokia in Estonia and Knorr-Bremse, Ericsson and Siemens in Hungary.

Generally, bottom-up activities are driving domestic innovation in candidate countries. This involves collaboration of industry with engineers and scientists or groups of researchers, and networking of enterprises. However, the **crucial issue for the further development of applied research in PACs is to wire-up the innovation system** by encouraging interaction between business, educational and research institutions. This requires flexible configurations and direct engagement of industrialists in the process of application of new technologies. It points towards corporate innovation networks, strategic alliances, and multidisciplinary research centres. Given that in many cases they are starting from scratch there may be opportunities for leapfrogging by the creation of new S&T institutions that match the demands of the knowledge society. For example:

- Build-in industry-university links from the start by co-financed laboratories and technology centres. Incentives for private sector researchers to work in higher education on a part-time basis. Flexible career paths between public and private research.
- Encouragement of intermediaries such as technology transfer centres, private research foundations, industrial associations, chambers of commerce and non-governmental organisations (NGOs).
- Development of poles of excellence in order to catalyse excellence and competence at the urban or regional level, by attracting leading researchers to join forces on projects of regional, national or international importance.

The establishment of an **environment that fosters innovation culture, encourages enterprises to innovate and protects industrial and intellectual property rights** is an important condition for building a coherent knowledge system and the take up of innovation and technological modernisation in candidate countries.

The third, vital, ingredient is scientific human capital. The abrupt decrease in research capacity in CEECs, the limited inflow of young people in research career and the more generalised threat of brain drain lead to **fears that the lifeblood of research is under threat**. The loss of talented people through emigration to Western Europe and beyond is probably less significant than the 'brain loss' of researchers leaving the scientific labour force altogether. However, for the whole society this loss might have had the positive effect of increasing the quality of workers in other economic sectors. For example, a positive by-product is that researchers may start their own technology-based companies and hence contribute to growth of innovation activities of the industry.

The market economy sets new **requirements for the R&D workforce to develop management and marketing skills** necessary for the competition for funding, for co-operation with industry and with the international scientific community. Significant policy attention is devoted in PACs also to **attracting young researchers into research careers**. One aspect is the targeted replacement and updating of the research equipment so that it is possible for researchers and university teachers to pursue a career in their home countries. Another aspect is the specialised training and the exchange programmes for students and young researchers. The rise in technical and engineering studies at undergraduate level might be a positive signal of a shifting balance towards more applied research.

How to preserve and build new assets and how to increase the research results and inflow of knowledge in PACs – are important issues that need to be addressed in order to bridge the gaps in research capacities in PACs. Paradoxically, possible solutions to brain-drain might lie in **enhancing the mobility of researchers in an enlarged EU**. The exchange of experience and new ideas, international and regional collaboration and innovation transfer could essentially contribute in the process of European integration and improvement of quality all round. It is necessary however also to make serious efforts to reverse the flows of researchers - particularly young researchers - from West to the East.

Learning capabilities

The process of building human capital and learning capabilities has three important aspects:

- Meeting the present skills gaps in the labour market;
- Guaranteeing the medium-term capacity of the S&T training system to deliver technical specialists, researchers and teachers;
- Ensuring the longer-term sustainability of society and economic growth by opening good-quality education to all citizens.

There are concerns that although PACs have a relatively well-qualified workforce the skills are outdated and not flexible enough. They do not **meet the demands for knowledge workers** in terms of technical skills, general ICT skills or transferable skills. There is evidence moreover that the gap is growing. This issue is thrown into starker terms when it is recognised that most PACs face a demographic decline in their labour force in the coming years. Reinforcing initial training is important but it will not be enough to meet the needs to retrain existing workers.

As regards the medium term, PACs are on the way to build open and internationally integrated higher education. In most CEECs, there has been a very rapid – perhaps too rapid – growth in private universities. Without considering the future consequences of the demographic decline for this increase in educational supply, there are now moves to assess education quality that will probably encourage a rationalisation of higher education. The

international recognition of the quality of teaching and research in higher education will emerge as an increasingly important issue in the development of higher education, not least because people want qualifications to be recognised by international firms and in international labour markets.

On the longer time horizon, the wider educational systems will require restructuring in order to deliver the new forms of content and to adopt new pedagogic methods, especially to achieve the **shift from traditional methods of instruction to learning**. Notwithstanding potential resistance from a demoralised, under-rewarded and ageing teaching profession, the coming years can only be confronted with confidence through innovations in pedagogic methods, including new tools and technologies, including e-learning.

However, due to the tight budgetary situation there is a **growing concern about severe inequalities and people being left out** of even basic education. Basically, people with monetary resources are increasingly buying their children out of the struggling state education system. This trend opens the way to a dangerous downward spiral in which the middle classes increasingly distance themselves from the state sector. These disparities have a particularly strong presence when looking at poorer regions such as declining industrial cities or rural areas. Although by such divisive trends **the education of the technological elite might be secured, they represent a societal time bomb** for the PACs. A cohesive society cannot be built if a large proportion of the citizens of 2010 and beyond are locked out of the fruits of the knowledge society.

Where next?

A report such as this can only scratch the surface of the wide terrain implied by 'technology, knowledge and learning' in candidate countries. A number of issues remain which might be further explored. How to ensure the widest participation in the knowledge society? Are there equal opportunities in S&T between women and men? How to encourage participation of all citizens in open and transparent S&T governance? In what ways are ethical concerns being addressed? The specific challenges and opportunities for PACs in these areas present possible targets of follow-up studies.

In the meantime, what futures do the S&T systems in PACs face on the 2010 time horizon? One possible way to look at this is through three scenarios of S&T specialisation profiles at regional and national levels:

- Full integration: all PACs are integrated into the global/EU S&T system and specialised in areas where they could offer excellence or have competitive advantage.
- Regional co-operation: countries and/ or regions consolidate into co-operative blocs in respect to S&T capacity, in some cases these blocs could transcend borders to create trans-national innovative regions or corridors.
- Uneven and multi-speed progress: big variations emerge with some PACs well integrated in the global/ EU research area and others struggling to find a profile.

Where candidate countries see their competitive advantages in S&T and which targets they set for future development might produce quite different levels of development. Some examples might be to aim at achieving the EU average R&D spending level by 2010 or to establish a more flexible career path for researchers. Others might focus on developing e-services and ICTs to speed up economic growth. Further priorities might emphasise wider knowledge society targets and efforts to make life-long learning a reality.

It would have been interesting to take the results of this phase of the Enlargement Futures work further, in order to attempt a future mapping of the knowledge, technology and learning systems in PACs. This would provide categorisations of PACs on different indicators and could provide the basis for a categorisation of different strategies for development relating to emerging economic and research specialisation profiles, demographic profiles and so on. However, the diversity of the different candidate countries and the lack of consistent and comprehensive indicators presented a real challenge. Thus, while such a project remains worthwhile, the primary requirement for further studies remains the improvement of the analytical base and the creation of procedures for comparability across countries.

Panel objectives and methodology

Objectives: The aim of the Thematic Panel on 'Technology, knowledge, and learning' was to focus on the development of the science and technology base in PACs and the challenges to innovation and education on the way towards a knowledge society. The main drivers and issues of change in PACs in these areas and the expected developments and outcomes on a 2010 time horizon were to be developed and specified in details. In order to achieve its objectives the Panel involved experts from PACs and EU member-states in an interactive process based on two workshops, supported by background research.

Preliminary phase: In the framework of global technological trends and on-going activities related to the European Research Area, the IPTS team considered it essential to take preliminary stock of current science and technology priorities in PACs in advance of the Panel's work. A draft document describing the policy framework and the declared S&T priorities in candidate countries was prepared before the first Panel meeting and validated by experts of PACs. As starting basis of the Panel's work, the IPTS team prepared also a Discussion paper and a draft Working paper, the later forming the basis for the full Panel report.

First Panel meeting (16-18 May 2001): The objective of the first meeting was to determine the main issues and challenges for PACs related to technology, knowledge and learning. In addition to the background papers, some important issues coming out of desk-research were incorporated into three questionnaires on S&T priorities, knowledge infrastructure and learning capabilities submitted to Panel members during the relevant sessions in order to support the brainstorming. On this basis the Panel provided a description of the top issues and identified the linkages between them.

Interim Period (June-September 2001): The dialogue with Panel members continued in preparing the draft Panel report. On the basis of a questionnaire, some Panel members provided new inputs and details on the main issues, as well as examples of good practice and country specific information, to be considered in the report. Besides, background research was carried out by IPTS in order to have comparable information for all candidate countries.

Second Panel meeting (17-19 September 2001): The draft Panel report was presented at the mid-term seminar of the 'Enlargement Futures' project in Prague, together with the draft reports of the other Panels. Subsequently, the Panel had a second meeting with the aim of reflecting on the guidance of the Steering Group of the 'Enlargement Futures' project, to discuss cross-cutting issues with other Panel reports and to focus on the possible future options. Three sub-groups were set up to consider opportunities for the future development in PACs in the areas of S&T priorities, knowledge systems and learning. The outcome of this was that some future options/models were identified related to some important factors – ICT dominance in research, education and the society at all; sustainability in research centred on 'star' scientists and reinforcing science-industry links; speed and scope of the integration of PACs in science, technology and education by 2010.

Preparation of final Panel report: After the 'Enlargement Futures' seminar in Prague, a draft final Panel report was prepared and circulated to Panel members by mid October. Their comments were incorporated in the final report published for a conference in Bled (2-4 December 2001).

Introduction

Why the focus on Technology, Knowledge and Learning?

In today's so-called new economy, learning and knowledge have become key success factors for international competitiveness with the result that intangible and immaterial resources have overtaken physical and tangible assets in order of importance[2]. This is reflected by a dramatic rise to the top of the policy agenda of knowledge-related goals.

Thus, the European Union embarked in March 2000 on the so-called Lisbon Strategy where the consensual aim is to make the EU by 2010 *"the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion ...//... through open methods of co-ordination and benchmarking"*. Research and innovation policy is set to become one of the key instruments for achieving these goals, and in particular, the European Research Area strategy promises to introduce a more consistent approach to pan-European collaboration and the prioritisation of public research[3]. Another major tool is the "eEurope - An Information Society for all" initiative, which aims to increase the take-up of digital technologies and to ensure that everyone has the skills to use them.

The scale of this challenge is already very daunting for the present EU members. The research and innovation lag of the EU with respect to the US is well documented. On top of this, the technology gap[4] between cohesion Member States and EU leaders (France, Germany, Finland, Sweden), has widened in recent years rather than narrowed[5]. The imminent accession to the EU of several new members in the coming years amplifies the challenge even further.

In this brief introduction we present an interpretation of what currently are the meanings behind the terms **technology, knowledge** and **learning** which policy has to adjust to, before coming to the specific focus of the analysis in this report.

Knowledge - what we know and what we can do - describes a state or potential for action and decision in a person, organisation or group. **Technology** is any *systematic* knowledge applied to practical ends such as problem-solving or extending human capabilities. **Learning** indicates some change in the state of knowledge often manifested by a change in understanding, decision or action. As such, these are fundamental in determining continued development in all human spheres - society (community, group identity, relationships), the economy (the material world, services, work and production), and the realm of ideas and culture (sciences, arts, philosophy).

In this report, the arguments we develop draw together data, arguments and prospective views that directly relate to priorities and concerns, which have emerged in the pre-

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[2] It is said that 25 - 50 % of economic growth derives from research and technology (COM(2000) 6) or 70 - 80 % from new and improved knowledge (Key note speech by Professor Charles Edquist Linkoping University, Sweden at The Learning Region and sustainable Development – The Case of the Oresund Region, Denmark/Sweden 'Building a Cross-border Learning Region' Organised by The Danish Ministry of Education, the Swedish Ministry of Education and Science, The Centre for Educational Research and Innovation (CERI) and the Territorial Development Service (TDS), OECD 17-18 June 1999, http://www.uvm.dk/konferencer/oecd/speeches.htm#charles)

[3] COM (2001) 79 final (March 2001), *Realising the European Union's potential: Consolidating and extending the Lisbon Strategy*. Contribution of the European Commission to the Spring European Council, Stockholm 23-24th March 2001

[4] in terms of the expenditure on R&D activities relative to GDP.

[5] European Commission, Second report on economic and social cohesion - Unity, solidarity, diversity for Europe, its people and its territory (adopted on 31 January 2001)

accession countries in recent years. These are mostly articulated in 'tangible' terms that are readily recognised by all concerned – research capacity, education system, investment and spending, technology transfer organisations, etc. – in short, the areas which are traditionally associated with knowledge and learning systems, and where some measures or indicators are available to guide discussion and debate. However, the discussion is informed by the broader more forward-looking view about what the future challenges for knowledge and learning systems are. Indeed, the two cannot be divorced one from the other. But the message that should be in the back of people's minds is that for the pre-accession countries (as indeed for the cohesion countries) there are many ways to the future and future prosperity. Catch-up, is just one of them, but countries do not necessarily have to follow the same institutional and capacity developing path that the present prosperous nations have done. Indeed, to do so might prove to be in some ways quite inefficient, as much of the knowledge infrastructure stock when lock-in occurs, becomes obsolete and a drag on further development. Leapfrogging ahead would seem to be a much more attractive and feasible prospect - especially in issues relating to knowledge and learning where brain power[6] is the determinant asset and available wherever there are people.

[6] see Romer (1998)

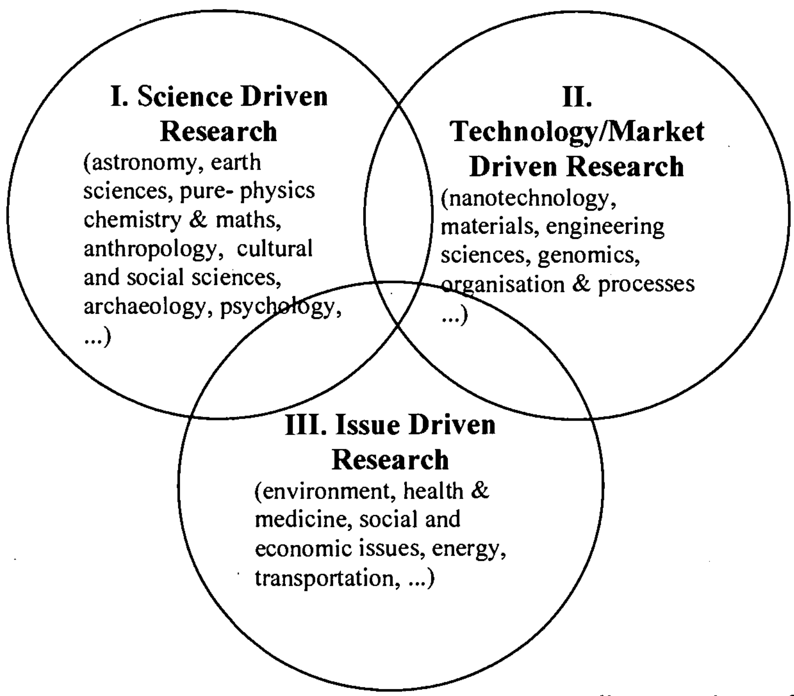
Chapter 1
Science and Technology Strategies

1.1 Science-, technology- and issue-driven research

Introduction

In recent years there has been a resurgence of interest in science and technology (S&T). On the one hand, there is renewed wonderment about on-going and dramatic scientific breakthroughs in nanotechnology, information technology and biotechnology, and all the potential applications in industry and society that the new knowledge heralds. On the other hand, many of these same developments elevate concerns that the pace of S&T is out of step with human society. That it runs ahead so fast and on such a colossal scale that it seems sometimes out of control.

Figure 1: Research drivers



This interest and these concerns signal a need for increased policy attention to S&T. On the one hand, it is necessary to examine the appropriate position of national innovation and research in respect of the frontiers of knowledge. This is particularly important given the escalating cost of maintaining high technology research capabilities. On the other hand, there is a pressure to make sure that policy supports technologies that are really in the service of mankind – i.e. those that meet our needs. For these reasons, S&T policy and priority setting is receiving increasing attention in all countries. The situation in pre-accession countries (PACs) is an interesting microcosm of this more general story given their needs to climb a development trajectory and to surmount particularly large challenges of finding adequate funding in order to achieve a restructuring and modernisation of their S&T base.

PACs face the challenge that they have to play the S&T game at a global level. S&T is no longer controllable at national or even European level, but follows breakthroughs that are taking place through the bottom-up efforts of the international research community in universities and public and private research centres. In the case of **science and technology/market driven** research (Figure 1) the pace and direction of change are largely driven by factors lying beyond national borders and policy instruments. National level policy is therefore limited to the more passive act of prioritising the areas to build strengths and aim at leadership and in which areas to adopt a follower position or let pass by.

But, on the other hand, **issue driven research** responds to policy goals, including permanent ones (*improving health & the quality of life)* and some more circumstantial or cyclical (*food safety, privacy & security, energy*). Here scientific research is driven by priorities that have been identified in some way as relating to national objectives. S&T in its basic or applied modes, understanding-orientated or technology-orientated is brought to bear in identifying solutions or making progress in one form or another.

- National S&T policy therefore seeks to strike an optimal balance between the different types of research whether it is driven by issues and policies or from within S&T.
- Moreover the dynamic nature of S&T means that priorities setting requires the support of forward-looking assessments of where the new emerging frontiers are and what the implications are for economy and society. This is one reason for the increasing interest in foresight studies.

Both these questions are tightly constrained by national S&T capability and competencies in research centres and universities and their level of integration in the international S&T system (see Chapter 2).

Future and emerging S&T frontiers

A review of four recent prospective studies gives some clue as to the frontiers of S&T in the coming ten years and beyond reveals a relatively consistent set of broad priority categories (see Table 1 and Annex II-2). In many cases S&T driven priorities are defined by their strategic potential. They may be important in terms of emerging opportunities: perhaps the research is an <u>enabler</u> of new (e.g. biogenomics) or wider multidisciplinary fields (e.g. nanotechnology). Opportunities can also present themselves in areas where leadership positions need to be maintained or built up. S&T priorities may relate to the complementary competencies needed to maintain and develop technological leadership. For example, ubiquitous computing calls for a range of skills in hardware, software and communications fields and other fundamental enabling technology fields (e.g. complexity, advanced materials, nanotechnologies).

If we look at the results of a number of recent national foresight studies (Table 2) we can see a strong orientation towards issue driven priorities such as environmental concerns, ageing population, quality of life or manufacturing performance (even if these are eventually translated into traditional technological categories seen in Table 1).

Table 1: Summary – key S&T driven priority fields

S&T field	Cited in:
Biotechnology	Millennium Project (UN) Global trends 2015/Scenarios 2025 Strategic Futures Emerging Thematic Priorities
Nanotechnology	Millennium Project (UN) Strategic Futures Emerging Thematic Priorities
Information & Communications Technology (Embedded Intelligence, Ubiquitous Computing, Wireless internet,	Global trends 2015/Scenarios 2025 Strategic Futures Emerging Thematic Priorities
New Energy sources	Strategic Futures Emerging Thematic Priorities
Cognitive science/ artificial intelligence/ knowledge management	Millennium Project (UN) Strategic Futures
New & advanced materials	Global trends 2015/Scenarios 2025 Emerging Thematic Priorities
Renewable and recyclable materials	Strategic Futures Emerging Thematic Priorities
Quantum Computing	Millennium Project (UN)
Planetary astronomy/space research	Millennium Project (UN)
Technology fusion leading to new disciplines	Global trends 2015/Scenarios 2025
Complexity and complex systems	Emerging Thematic Priorities

Table 2: Key societal topics in recent and on-going foresights

Key theme	Main foresight theme
Sustainable environment	8
Energy	9
Built environment, urban life, housing and use of physical space	6
Knowledge, skills, lifelong learning, training	5
The future of manufacturing	5
Healthier living	5
Global competition and integration	4
Ageing of society	4
Mobility and communication	3
Changing patterns of working life	3
Ethics and privacy	2
Values, Culture and Social Cohesion	2
The Organisation of Society & Democracy	2
Crime	1
Enlargement	1
Sample: Fondazione Roselli, Italy (on-going), German Futur (on-going), Norway (on-going), Sweden 2000, United Kingdom 2000, IPTS Futures Project 2000, Austria 1998, Japan Sixth Technology Delphi 1997 Portugal 2000, Spain 1999 & 2000, Australia 1997, RAND Critical Technologies US 1998, New Zealand 1998, Ireland 1998	

Turning now to statements from national S&T plans in PACs we can see a similar mix of S&T led and issue led priorities (Box 1). But there are a series of policy issues regarding the translation of objectives in plans into effective S&T activities and outcomes.

Box 1: S&T in PACs - where to focus?

Experts suggest that there are two categories of S&T areas of research to be considered:

- key areas for PACs in general – Information and communication technologies (ICTs), ageing population, environment, basic science, knowledge development areas, policy research
- country-specific – technology areas focusing on the individual needs and local/regional specificities and differences in PACs in terms of cultural roots, environment and historical development.

Some of the key S&T areas by country include:

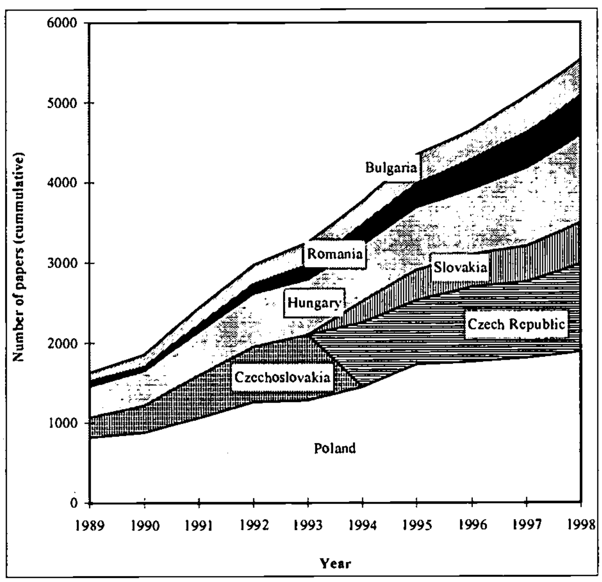
- In **Estonia** three key government-approved areas – user-friendly information society, biomedicine, advanced materials. In each area a national programme will be developed.
- In **Bulgaria** high importance is accorded to S&T in high-technology areas, e.g. information technologies, telecommunications, new materials, biotechnologies, pharmacy, precise chemistry, new sorts of plants and animal breeds, gene engineering, etc.
- In **Cyprus** S&T research priorities include water resource management; protection and sustainable development of land, coastal and aquatic environment; preservation of cultural treasure; development of innovative educational system; restructuring public institutions; tourism management; alternative energy sources.
- In **Hungary** there are five broad areas guiding S&T research – quality of life, ICTs, environmental and material resources, agro-business and biotechnology, national heritage and contemporary social challenges.
- In **Slovenia** funding priorities include ICTs, advanced materials, complexity and systems, knowledge, science and technologies for sustainability. A specific focus is the natural and cultural heritage.
- In **Poland** competence exits in basic research in genetic engineering and natural sciences. Research on natural resources is lacking in spite of the large existing coal industry.
- In **Turkey** the emphasis is on ICTs, agriculture, biotechnologies, education and human resources oriented technologies, technologies for sustainable development, and (in relation to productivity improvement) automation technologies and tools for textile and food industry.
- In **Malta** country specific areas are: ICTs (e-government local services, services for people with special needs, e-commerce Financial services), distance learning, microelectronics, software and multimedia development; fish farming, environmental farming, waste management, biotechnology and health-related products, tourism and related services, land management and sustainable use of land, environmental protection (marine environment and resources), energy management, water technologies, cultural identity and linguistics, R&D needs of SMEs - exploitation of research results, cultural heritage and tourism).
- In **Lithuania** S&T areas to focus on include – information technologies (for health, networking, tele-work), biotechnologies & genetics, nuclear research, mechatronics and microsystems. Specific priorities relate to Lithuanian language (translation tools) and cultural heritage (digitalisation, multimedia form).
- In **Latvia** five key areas are approved by the government – material sciences, biomedicine, information technology, forestry and wood sciences, lettonica (national cultural heritage and language).

Regarding global trends and European priorities, in particular the RTD Framework Programme, all PACs identify ICTs as research priority and as having a special place in all PACs as enabling technologies for all sectors of economy. Most countries focus on potential application to development of new products and services, new technologies for language translation and speech recognition, for digitalisation and presentation in multimedia forms of cultural heritage.

Science-driven research

To achieve excellence, it is increasingly necessary to play in the front ranks of the global science. Many PACs certainly have a potential to achieve excellence, drawing on traditions of contribution to fundamental science and historically prestigious universities. Indeed, despite downscaling of research capacities and infrastructures in Central and Eastern European Countries (CEECs), contribution and participation in fundamental research seem to be rising fast. The opening up of PACs research systems, and the influx of foreign funding, is leading to a considerably greater (re-)integration of PACs into the international science base, especially for countries with scientific traditions going back to the middle ages (e.g. Hungary, the Czech Republic). This is reflected at present in a rise of co-publishing (Figure 2) and common projects with EU15 scientists. Of course this is nothing new also in countries with more open traditions, such as Cyprus and Malta, where an international orientation stems from the fact that a majority of tertiary level students leave their home countries to study abroad. This includes graduates of the Higher Technical Institute in Cyprus the main tertiary vocational education provider, which sends 50% of its graduates abroad each year mainly to the US and the UK. Such flows almost certainly lead to strong international links amongst research groups.

Figure 2: Publication activities of some PACs: papers co-authored with EU15 countries



Source: Meske (1999)

Despite this potential there are issues facing the future of fundamental research.

- Is it possible to maintain and enhance high scientific output and in what areas?
- What investments are required in equipment and facilities to allow cutting-edge science to continue?

Fundamental scientific performance certainly appears as a priority in the National S&T Plans.[7] They are either acknowledged in a generic way (Estonia) or in terms of explicit but broad general priorities (Czech Republic - several areas of natural sciences; Estonia, Latvia & others – national cultural heritage and language). This is in line with a wider perception that fundamental research is vital across the whole spectrum of knowledge

[7] see Annex III

creation and investigation. But, science driven approaches require openness to diversity, high-risk and long-term ideas stemming bottom-up out of scientific communities. In particular, there are many areas in which the scale of investment in scientific infrastructure calls for modes of co-ordinated approaches (international networking, large-scale projects). This calls for explicit and detailed prioritisation in order to make sure that the implications of entering into the long-term support for these fields of science (rather than others) are well understood. For example, big science facilities (particle accelerators, synchrotrons, radio telescopes or shared Internet infrastructures for e-Science) may not be achievable by countries or institutions acting alone. It can also be necessary to prioritise efforts aimed at raising the effectiveness of networking in emergent areas of research to create viable levels of research interaction and support for nascent or widely dispersed research communities.

Technology/market driven research

Whilst fundamental science has held up quite well in PACs over the past decade, applied research in CEECs has faced a major downsizing. This has accompanied the collapse of industrial research activity and the privatisation of public enterprises. Only in Romania and Lithuania have significant applied research capacities survived, at least up till 1999[8]. In the others, notably the Czech Republic, capacities are being revived progressively.

In general, there is an urgent need to redress the balance in the R&D systems and to increase or further adapt applied research to serve the needs of a technologically advanced economy. This cannot be done in a generic way, but needs to single out some specific priorities. As in fundamental science, advances are occurring at an accelerating pace and even in the most advanced countries, making progress and keeping up to the state-of-the-art is increasingly contingent on the concentration of resources on fewer and fewer priorities. For PACs, this prioritisation task also applies, but is complicated by the more basic "catch-up" need to (re-) establish critical competencies and capacities in the key areas chosen, compensating for the ten-year applied research and technology slump.

The policy and strategy statements and reports of ministries, S&T agencies, national research and industrial innovation strategic plans across all the PACs reveal a consistent pattern of research priorities. As we note above, there is frequent reference to high-tech areas such as ICTs, materials, biotechnology combined with some nationally specific priorities (e.g. natural resources, forestry or fisheries, linguistic factors). It is frequently difficult to appreciate how the broad S&T priorities are specified at a finer level of detail. It is also very difficult to discern from available information the existing levels of S&T competencies and capabilities in the different countries, and the extent to which the level of research in the different areas justifies investing or earmarking resources. This information is a vital precursor to any discussion on the significance of foresight priorities for applied technology-oriented research in the PACs and on what the future prioritisation strategy should be.

An essential early step in this process is the benchmarking of the supply side of S&T competencies. This is difficult given that it is composed of a complex array of expertise and resources including:

- Individuals (eminent scientists, professors, practitioners, inventors, ...)

[8] See European Commission DG Research (1999)

- Research & development teams & groups (specialist expert teams whether in public or private institutions, laboratories)
- Institutions & organisations (this could be Universities, or faculties within universities, public research organisations, branch-research organisations, private consultancies, companies etc.)
- Networks (of either individual scientists, of teams or organisations) at local, regional, national and European/International levels

Such benchmarking is very difficult and extremely politically sensitive, especially given the problems to arrive at reliable judgements. For example, excellence and competence is as much a product of factors such as social and cultural resources, organisational routines and ways of doing things, as it is of individuals.

In all cases, the significance and importance of assessing what constitutes existing capacity, what capacity might be achievable and what capacity lies dormant. This assessment of capacity can be done against a number of different criteria and can indicate whether the investment might pay off in terms of returns at the national level.

- How does it compare with world-class performers in the area? And what would be required to achieve comparable performance?
- Is domestic demand sufficient to support a high quality research capability?
- Could domestic research capacity eventually access international markets?
- Can the activity achieve sufficient critical mass in order to be sustainable?
- If not, can national efforts integrate into larger trans-national efforts?

As an example, a lot of encouragement has been given to develop high-visibility and high-performing centres of excellence in several PACs (sometimes through the EU's Fifth Framework Programme). Estonia, for example has focused policy on the fostering of centres for strategic competence at the Tartu University and Tallinn Technical University in the fields of biotechnology, information technologies (IT), materials and environmental technology (e.g. the Centres of Material Science and Gene/Biotechnology at Tartu and Tallinn). These can be seen as *Achievable Capacity*. Alternatively, already in 1996, a review of industrially oriented research capacity identified 15 units possessing a unique position in Poland, 21 units whose activities could be taken over by other units, and 18 units whose existence could not be explained[9]. This is more in line with the assessing *Existing Capacity*.

Further insight is gleaned from the results of a proposal-based evaluation of centres of excellence in 12 PACs (excluding Turkey) carried out in the context of the international co-operation part of the Fifth Framework Programme[10]. The 'call for proposals' in question specified that centres should bring together theoretical and applied research and cover the natural, social and economic sciences, using, where possible, a multidisciplinary approach. Excellence was measured against a set of six S&T criteria, one social objective criterion, two economic development criteria, and six resources, partnership and management criteria. A total of 101 out of 185 proposals received passed the S&T excellence threshold criteria, of which 34 were short-listed following evaluation over the complete criteria set (see Table 3 below).

[9] European Commission DG Research (1999), p. 178.
[10] see Rhode (2000)

Table 3: PAC Centres of Excellence		S&T Areas							
Rank	Institute	Biosci	Medical	Environ.	Engineer	Materials	Physics	ICTs	SocEcon
1	Institute of Genetic Engineering - *Kostinbrod, BULGARIA*	X							
2	Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Cybernetics - *Prague, CZECH REPUBLIC*							X	
3	Collegium Budapest, Institute for Advanced Study - *Budapest, HUNGARY*								X
4	Hungarian Academy of Sciences, Institute of Experimental Medicine - *Budapest, HUNGARY*		X						
5	Polish Academy of Sciences, High Pressure Research Centre - *Warsaw, POLAND*						X		
6	Estonian Biocentre-*Tartu,Estonia*	X							
7	Institute of Solid State Physics, University of Latvia - *Riga, LATVIA*					X			
8	Institute of Experimental Endocrinology, Slovak Academy of Sciences - *Bratislava, SLOVAKIA*	X							
9	Alfréd Rényl Institute of Mathematics, Hungarian Academy of Science - *Budapest, HUNGARY*							X	
10	Institute of Biochemistry and Biophysics PAS - *Warsaw, POLAND*	X							
11	Wroclaw University of Technology, Institute of Production Engineering and Automation - *Wroclaw, POLAND*				X				
12	The Jan Zurzycki Institute of Molecular Biology - *Cracow, POLAND*	X							
13	Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences - *Prague, CZECH REPUBLIC*				X				
14	Institute of Fundamental Technological Research, Polish Academy of Sciences, Centre of Mechanics and Information Technology - *Warsaw, POLAND*					X			
15	University of Cyprus, Centre for Banking and Financial Research - *Nicosia, CYPRUS*								X
16	Central Laboratory for Parallel Processing, Bulgarian Academy of Sciences - *Sofia, BULGARIA*							X	
17	Polish Academy of Sciences, Division of Food Science, Institute of Animal Reproduction and Food Research - *Olsztyn, POLAND*	X							
18	Polish Academy of Sciences, Institute of Physics - *Warsaw, POLAND*						X		
19	Danube Delta National Institute for Research and Development - *Tulcea, ROMANIA*			X					
20	Institute of Cellular Biology & Pathology "Nicolae Simionescu" - *Bucharest, ROMANIA*		X						
21	Centre of Molecular and Macromolecular Studies of Polish Academy of Sciences - *Lódz, POLAND*	X							
22	Institute of Mathematics "Simion Stoilov" of the Romanian Academy - *Bucharest, ROMANIA*							X	
23	"Horia Hulubei" National Institute for Physics and Nuclear Engineering - *Bucharest, ROMANIA*						X		
24	Polish Academy of Sciences, Institute of Mathematics - *Warsaw, POLAND*							X	
25	Computer and Automation Research Institute - *Budapest, HUNGARY*							X	
26	Biological Research Centre, Hungarian Academy of Sciences - *Szeged, HUNGARY*	X							
27	UNESCO Associated Centre of Excellence for Research and Training in Basic Sciences - *Vilnius, LITHUANIA*	X							
28	Institute of Experimental Medicine, Academy of Sciences of the Czech Republic - *Prague, CZECH REPUBLIC*		X						
29	Research Institute for Solid State, Physics and Optics - *Budapest, HUNGARY*						X		
30	Centre for Transportation Research - *Zilina, SLOVAKIA*				X				

31	Institute of Oceanology - *Varua, BULGARIA*			X					
32	Institute of Physics, Univ. of Tartu - *Tartu, ESTONIA*					X			
33	Agricultural Research Institute Soils, Water use and Env. - *Nicosia, CYPRUS*	X							
34	National Institute of Chemistry - *Ljubljana, SLOVENIA*						X		
	Total	10	3	2	3	3	5	6	2

The main implications which were drawn from the results of this evaluation were:

- excellence in life sciences has emerged over the past 10 years
- excellence in physics is in decline: old equipment / leadership of old areas
- mathematics - still excellent, fundamental still, isolated, however big opportunities when linked up with ICT
- investment in environmental research is lacking, as well as in environmental technologies, in particular in energy research
- engineering is floundering without industrial links
- materials research is fragmented without strategies
- qualitative independent socio-economic research is lacking

Issue driven research

Existing or potential supply-side capacity only gives part of the picture needed to establish priorities. Also needed is explicit consideration of the future economic and social relevance of research. The risk of a growing mismatch between research activities and industrial and social needs has to be countered. This is seen in some of the national S&T plans where there are references to nationally specific factors such as culture, language, as well as long-term trends that affect national and regional development. Looking at the stated research priorities for PACs, they reflect the same dominance of societal and socio-economic rationales and objectives as elsewhere, in particular the way emerging themes identified through EU Member State Foresight exercises are formulated. However, it is not necessarily the case that the emerging priorities benchmarked from national -level or EU15 Foresight exercises are appropriate or best for PACs, nor that they apply to an enlarged EU.[11] Thus we can ask:

- Do these priorities correspond to the type of research and competencies really needed? If not, why not and what then should the specific priorities be - in addition or alternatives?
- Do the EU level foresight priorities provide a useful starting point for the PAC priorities? How should they be adapted and why?
- Are there particular S&T themes determined by local conditions, specialisation, geographic specificities that are generally relevant to transition countries but not necessarily to other European countries?

Research activities need to be guided by plausible future visions and scenarios of social and economic development as well as contributing to the construction of such visions.[12] A further need exists to build a good reference system with benchmarks, and indicators. Information systems on scientific improvements and technologies need also to be

[11] Some national R&D plan priorities are very close indeed to the foresight priorities, e.g. Romania - complex systems for environmental management, micro & nanotechnologies, natural or created risk prevention, protection & rehabilitation, food security.

[12] The scenarios & strategies method applied recently by the EU-agencies Cedefop and ETF in the field of education and training may be particularly useful and could be more widely adopted, because its merit is mainly to bridge gaps at the interface between research and policy or practice - Cedefop: European Centre for the Development of Vocational Training, Thessaloniki/Greece, ETF: European Training Foundation, Turin/Italy. See: Sellin et al (2000)

introduced. For example, a recent study of innovation in six candidate countries (Cyprus, Czech Republic, Estonia, Hungary, Poland and Slovenia) found a relative absence of robust data on innovation performance in these six candidate countries suggesting that policy choices are being made on the basis of very partial and non-robust indicators.[13]

National priorities in ERA

It is clear PACs need to follow a prioritisation strategy that closely couples to specific national considerations (physical resource endowments, geographical location, building on traditional areas of competence, increasing the technological intensity & re-awakening the demand for R&D of indigenous businesses).

But a paucity of resources drives PACs (as indeed also happens in some present Member States) towards aligning national technological priorities with those of the EU RTD Framework Programme in order to access funding. This of course has many benefits (better integration into EU-wide research system and networks, high-level technological co-operation and exchange, etc.) but a danger exists that priorities not reflected in the Framework programme are pushed aside. It is obvious that candidate countries need to focus on important European *and* global necessities that are highly relevant and necessary for their development, such as ICTs. However, they also need to find niches of excellence for possible national S&T specialisation closely linked to the industrial patterns of specialisation and needs.

One important component of a resolution to such problems is the construction of a clear view of way ahead (where we are, what we are capable of and where we want to go). The on-going re-structuring of industry suggests that it is hardly feasible now to set up research priorities for the longer term. However, focusing at present at the short and medium time dimensions, some procedures might be elaborated for the longer-term priority setting process based on global drivers and national/ local issues and real capacities.

1.2 Effective governance of science and technology

Introduction

The deep structural changes that PACs have confronted in the past ten years pose significant challenges to all institutional systems including S&T. These issues affect two related but conceptually different areas of S&T governance[14]:

- To achieve an effective and open management and support of a scientific infrastructure and the design, content-specification, delivery, selection and evaluation of S&T programmes;
- And to implement good practice in respect to the specification and implementation of technical standards[15].

The efforts by PACs to achieve such transformations in S&T governance take place against pressure to fall into step with EU practices, which stress the need for transparency & openness, participation & inclusion, accountability, effectiveness and coherence.[16]

[13] European Commission DG Enterprise (2001)
[14] See Shepard (2000)
[15] Technical factors are for instance pollutant limits, pharmaceuticals licensing, vehicle safety standards, etc.
[16] COM (2001) 428 final, White Paper on European Governance

This is an area of high policy attention due to rising concerns that the public is politically apathetic and has lost confidence in the political ability to find solutions to major problems confronting our societies.

This section concentrates on the governance of S&T priority setting and implementation. For the most part, the present PAC systems are driven by sectoral or ministerial agendas rather than achieving a comprehensive mapping of developments. There are however emergent examples of new practices in some countries based on Foresight. Such approaches are more crosscutting and longer term and may provide new avenues for developing more effective and transparent S&T governance systems.

The efficient governance of the S&T in PACs requires not only an efficient forward-looking policy building process. It is also important to consider how the policy objectives will be paid for and practical aspects of turning action plans into financial measures. Part of the reason for aiming at better co-ordination of stakeholders is to reduce redundancies in research. The usage of new tools and mechanisms for efficient distribution of the limited financial resources for R&D and the evaluation of the results are the key for better investment in S&T.

Issues of S&T governance in PACs

Sectoral approaches still dominate the preparing policy documents in the areas of research, innovation, industrial development and small- and medium-sized enterprises (SMEs). As a result there is often a lack of integration between research agendas and economic policy, duplication of research and mismatch between policy plans and financial flows.

Responsibility for innovation is typically split across a number of state bodies covering industrial and technology policy and/or research and education and/or SMEs. Only in Estonia, Latvia and Poland the governments have defined policies or strategies addressing innovation as a separate policy area. In Cyprus it is dealt with as part of industrial policy, in Slovenia under the heading of technological development, and in the Czech Republic in terms of both industrial and research policy.

Table 4 gives an overview of the authorities involved in the design and implementation of R&D and innovation policies in PACs. The mismatches in the policy of the different responsible bodies, and sometimes the conflicting incentives for enterprises and research units seriously affect implementation. One of the consequences of low co-ordination between respective governmental departments is that policy initiatives are not always directly supported by effective financial instruments. While, the multiplicity of research branches at ministry level and the different funding structures for SMEs, regional development and technological development[17] make it very difficult to avoid duplication of measures.

[17] see Annex III

Table 4: S&T framework and relevant authorities[18]

Country	policy documents	national authority	legal measures	support structures
Bulgaria		Ministry of Education and Science National council on scientific and technologic policy	Higher Education Act Act on Establishment of the National Centre for Agricultural Science	National Science Fund
	National Strategy for development of high technology activities (1999)	Ministry of Economy Agency on SMEs	draft Law on High-Technology Parks and High-Technology Activities Law on SMEs	Encouragement Bank
Cyprus	1999-2003 Strategic Development Plan	Planning Bureau		Research Promotion Foundation
	New industrial policy of the government for the development of high-technology industry in Cyprus			
Czech Republic	National R&D Policy (2000) National Programme of Oriented Research	Ministry of Education, Youth and Sports Research and development Council	Higher Education Act	Grant Agency
	Programme of the Support of innovative Firms in Business Innovative Centres	Ministry of Industry and Trade		Technology Centre at the Academy of Sciences
Estonia	Knowledge based Estonia (2001) Learning Estonia (2001)	Ministry of Education Estonian Research and Development Council	Organisation of Research and Development Act (1997)	Estonian Science Foundation Science Competence Council Regional Agreement for Baltic Higher Education, Archimedes Foundation
	Estonian National Innovation Programme (1998)	Ministry of Economic Affairs		Estonian Technology Agency
Hungary	Science and Technology Policy 2000 National research and development programs (2000)	Ministry of Education Science and Technology Policy Council Science Advisory Board	Bill on higher-education (1994) Bill on Hungarian Academy of Sciences (1994)	Higher Education Development Fund National Scientific Research Fund National Technological Development Fund
	Medium-term strategy for the development of SMEs	Ministry of Economic Affairs Enterprise Development Council	Law on SMEs	Hungarian Development Bank SME Target Fund Economy Development Fund Regional Development Fund
Latvia	National concept on Research Development	Ministry of Education and Science Latvian Council of Science	Low on research activity (1992) Low on higher-education institutions (1995) Law on Education (1998)	Regional Agreement for Baltic Higher Education
	Concept on the development of the National Innovation System (2001) National programme for the development of SMEs (1997)	Ministry of Economy		Latvian technological centre Latvian technology park

[18] see Annex III for details

Lithuania	Programme on computer network and Internet Services for Lithuanian science and higher education (2000)	Ministry of Education and Science	Law on Higher Education Law on Science and Studies	Regional Agreement for Baltic Higher Education
	Medium-Term Economic Strategy (until 2005) Medium-Term Industrial Development Policy (2000) Business Innovation Programme (2000) Small and Medium-sized Business Development Strategy until 2003 (2000)	Ministry of Economy Small and medium-sized business development Agency	Law on small and medium-sized business development	SME Promotion Fund
Malta	National Science and Technology Policy Document (1994)	Ministry of Education Malta Council for Science and Technology		Foundation for Science and Technology
Poland	Basis for National S&T Policy (1993, add. 1996) Guidelines for innovation policy in Poland (1994, add.) Directions of National Innovation Policy till 2002 (1999)	State Committee for Scientific Research	Act on the State Committee for Scientific Research Act on Research and Development Institutions draft Law on Higher Education	State Committee for Scientific Research
	Programme for support of development of regional institutions involved in technology transfer	Ministry of Economy		Agency for Techniques and Technology
Romania	National Plan for Research, Development and Innovation for 1999 – 2002 (1999)	Ministry of Education and Research National Agency for science, technology and innovation		
Slovakia		Ministry of Education Office for strategy of society, science and technology		
	Conceptional orientation of technological policy of industrial branches of the Slovakia up to 2003 (1999)	Ministry of Economy National Agency for Development of SMEs	State Aid Act	Government support program Start 2000
Slovenia	National Research Programme (1995)	Ministry of Education, Science and Sport	Law on Research activities (1991) Higher Education Act (1999)	
	Technology Policy of the Government of the Republic of Slovenia (1994)	Ministry of Economic Affairs	Act on Support of companies developing new technologies Law on promotion of technological development of Slovenia (1999)	Slovene Development Corporation, Small Business Development Center, Small Business Development Fund
Turkey	Turkish Science and Technology Policy 1993-2003 Turkish Science and Technology Policy Document 2003-2023 (under preparation)	The Scientific and Technical Research Council of Turkey - TUBITAK	Decree on R&D support (1995) Law on Science and TechnologyPolicy State Aid Act Law on Technology development zones (2001)	
	Five Year Economic development plans Industrial R&D support Programme	State Planning Organisation		Small and medium industry development organisation, Technology Development Foundation of Turkey, Technology Monitoring and Evaluation Board

It is not that co-ordinated research and enterprise policies are not recognised as critical. Indeed, many countries have set up advisory bodies (research councils) precisely to carry out the policy decisions and the co-ordination of research and development at governmental level.[19] But, the necessary operational links between the different actors in the innovation system are not yet developed enough to achieve efficiency. On the other hand, only a few councils (Cyprus, Czech Republic, Latvia & Turkey) also have functions related to co-ordination of the financial flows and the policy implementation and evaluation. The establishment of policy implementation institutions at some of these councils (in Cyprus, Malta, Turkey) is a step towards improving the overall performance of the R&D system.

Foresight as a tool for balanced S&T policy

The institutional fragmentation is both cause and symptom of a problem that the major stakeholders in innovation are not integrated in the determination of research and innovation priorities. Governments have traditionally been the main supporters of research and the public sector research agencies remain powerful, while the interests of innovative enterprises have not yet been formed.[20] A central challenge for governance therefore is to balance the supply-side and demand-side interests in setting research agendas, including service sectors and societal interests as well as manufacturing and agriculture. Generally, governments of PACs are aware of the importance of the involvement of industry in R&D and most governments have developed policies that support industrial R&D. But industrialists claim that research priorities are defined without consultation and are targeted towards topics where funding schemes are available. Small to medium sized enterprises are also often left out and, although this is a general problem for all countries, the importance of SMEs in the domestic economy of candidate countries makes the situation more serious. The voice of societal actors seems even weaker, and smaller attention is paid to democratic and human needs and to balance competitiveness against unemployment, inequality, sustainability and risk, ethics or the place of women in science.

An awareness is emerging of the need to increasing the number of voices that are heard in the setting of S&T priorities and for new patterns of communication and interaction in formulating policy, especially at a time of fast technological change and sparse resources. One sign that this is happening has been the recent growth of interest in foresight studies as a basis for strategy and policy planning activities of public bodies and as tools for managing an open process of determining priorities, to obtain maximum benefit for society, sustainable development and competitiveness of the economy (Table 5).

In ***Cyprus***, for example, foresight might centre on the problems of reintegration of a divided society outlining the way to build an integrated society based on mutual respect and co-operation. This implies changes in the education system and economic activities to achieve a constructive co-operation of the Greek and Turkish communities. Another important issue for the foresight activities is developing a national economic strategy based on strengths and traditions, in the context of Cyprus' place regionally and in Europe. The development of Cyprus as a regional portal of educational services and research centre is another topic for a future prospective study.

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[19] National council for S&T policy in Bulgaria, R&D Council in the Czech Republic, Estonian R&D Council, S&T Policy Council in Hungary, Latvian Council of Science, Malta Council for S&T, Supreme Council for S&T in Turkey

[20] Innovation&Technology Transfer, March (2001), http://www.cordis.lu/itt/itt-en/01-2/dossier.htm

Table 5: National Foresight and planning activities in some PACs

Country	Responsible institution	Mechanism / method	direct link to R&D policy	Time horizon (years)	Follow-up actions / results
Bulgaria	Ministry of regional development	Panels of experts, SWOT analysis, sector studies	no	2000-2006	National plan for economic development
Czech Republic	Ministry of Education, Youth and Science	Panels of experts,	yes	2001-2004	Priorities for oriented R&D
Hungary	Steering Group and National Committee for Technological Development	Panels of experts, scenarios, Delphi survey	yes	2000-2020	National innovation strategy
Latvia	Ministry of Economics	scenarios, modelling, SWOT analysis	no	2003-2025	Macro-economic development
Poland	Programme management team (involving members from Ministry of Science, Ministry of Economy, Ministry of Finance, Ministry of Health, Ministry of Ecology)	Delphi survey, Panels of experts	yes	no data	R&D Technical Foresight
Slovenia	Ministry of Economic Affairs	Panels of experts	yes	2010-2015	National development Programme (from 2003)
Turkey	Scientific and Technical Research Council of Turkey	Delphi, scenarios, panels	yes	2003-2023	Policy planning

In ***Estonia*** foresight is focusing on national issues such as: conservation of environment, quality of life, ethnic sustainability and regional concerns such as water and air pollution; energy production and distribution; transportation systems; communication and information technologies; bio- and gene engineering; continuous education; distribution of workplaces throughout the territory of the country. Since Estonia is a small country those studies predominantly concern positioning in the international context and with respect to neighbouring countries.

In ***Bulgaria*** there is no formalised Foresight study taking place, but the Ministry of Regional Development is orchestrating a panel of experts, undertaking a SWOT analysis and a sectoral study to feed in the National plan for economic development (2000-2006). This activity is like a mini-Foresight process, since it uses prospective techniques and it is organised in a participative manner with the active participation of the relevant stakeholders.

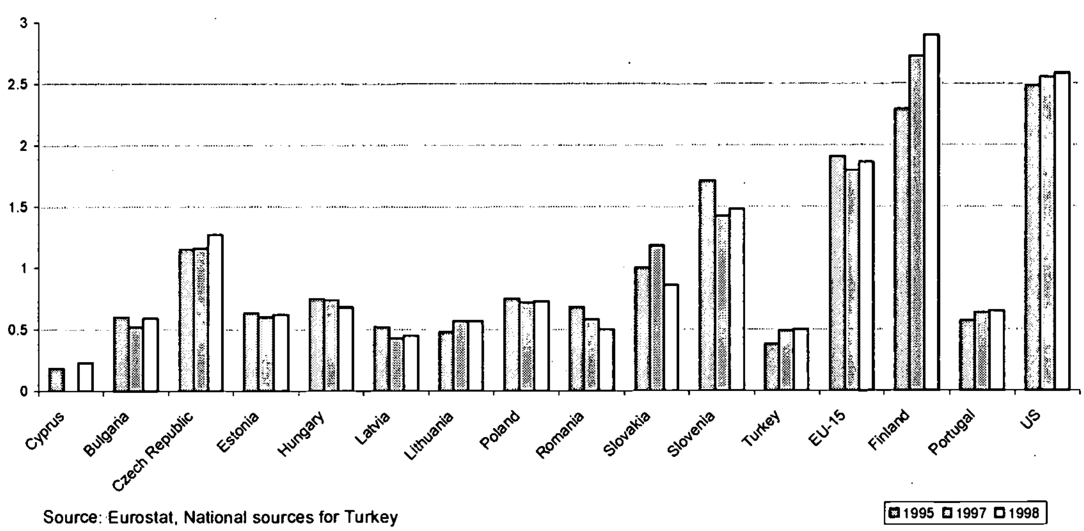
Possibly the best practice in the PAC context is the ***Hungarian Foresight Program*** – which has been the first foresight program in Central and Eastern Europe launched in 1997. The main aim of the Program was to bring together business, the science base and government to analyse the trends in technological development; world market opportunities; strengths and weaknesses of the Hungarian economy and R&D system, and on this basis of the Foresight outcomes to elaborate a national innovation strategy.

Another goal was to join intellectual forces of Hungarian researchers, business people, and government officials to discuss on current and future competitive position of Hungary in a globalised market. In the Program strong emphasis is given on scenario-building at macro-level and panel levels, as well as regional scenarios related to the development of the Central and Eastern European region.

Need for better investment in research

As a result of the lack of co-ordination between agencies and instruments, almost all PACs show signs that funding mechanisms are not meeting targets or fail to provide the correct incentives for companies to innovate. For example, rules attached to loans for industrial R&D may mean that only larger firms with low-risk projects can apply. Moreover, it has been hard for decision-makers in PACs to focus on measures to support the creation of innovative start-up firms at a time when many of the largest employers were going bankrupt. The need to deal rapidly with a large number of urgent legislative and policy changes, such as carrying out comprehensive health and social reforms has made it hard for PACs emphasise the apparent luxury of building a knowledge-based society. Although the investments in education and research may give a higher rate of return[21] than public welfare spending or infrastructure development, the available funds for R&D are very limited and a serious decline of the R&D budgets in the transitional period have been observed in all CEECs. The position now in most PACs, is that gross domestic expenditure on R&D (GERD) is significantly below the EU15 average of around 2% (Figure 3). A cluster of PACs achieve roughly equivalent levels to some EU member states at around but mostly below 1.5% (Slovenia, Czech Republic, Slovakia). Then there is a cluster from about 0.8% to 0.4% (Poland, Hungary, Romania, Estonia, Bulgaria, Latvia, Lithuania and Turkey) followed by Cyprus at 0.2%.

Figure 3: GERD as % of GDP



Source: Eurostat, National sources for Turkey

In addition, appraisals of the effectiveness of innovation instruments are scattered, only Hungary undertakes systematic evaluations of programmes funded in favour of applied R&D programmes involving experts of the EU.

[21] OECD (1998)

Financial mechanisms and tools

In order to promote S&T, innovation and SMEs, a large number of funding institutions, both state-run and private, have been established in candidate countries (see Table 4). Similarity in the practice prevails in PACs for distribution of the limited financial resources using as main instruments subsidies, thematic grants and grants for projects. A common feature is the use of competitions to award finance for new R&D projects relating to national policy objectives and priorities. It is becoming less common that money is directly earmarked to research units in the form of fixed institutional budgets. Even so funding systems are poorly configured due to the lack of active restructuring policies regarding the R&D sector, poor clarity of methods for establishing priorities and criteria for funding, as well as the absence of monitoring and evaluation of the research results. At the moment the situation is more a matter of islands of best practice and generalised good intentions (Box 2).

Box 2: Examples of good practice related to the funding of R&D

In ***Hungary***[22] the following main funds have been set up to allocate grants or favourable loans:

- Higher Education Development Fund - to finance the development of the infrastructure of higher education;
- National Scientific Research Fund - to finance basic research;
- Central Technological Development Fund - to promote technological development;
- "Szechenyi Plan" funding scheme - a relatively new funding scheme, supporting exclusively business-academy collaborations.

Grants or favourable loans are available for practically all Hungarian researchers or organisations (firms, university departments, other R&D units) awarded through three main schemes:

- *R&D infrastructure projects* - a 'bottom-up' scheme introduced in 1991 with major goals: to upgrade the R&D and educational infrastructure (e.g. to provide grants to purchase PCs and various tools); to facilitate the dissemination of R&D results (e.g. grants to attend conferences abroad if the applicant's paper is accepted, and contribution to organise conferences in Hungary);
- *Applied R&D projects* – another 'bottom-up' scheme, also introduced in 1991. Project proposals are evaluated by independent technical and financial experts in three stages and in most cases an interest-free loan is provided;
- *Target-oriented national projects* - a 'top-down' scheme, introduced in 1992. Four major goals are selected for support from public funds: disposal of nuclear waste, development of geographic information systems, food processing and packaging technologies and machinery and automotive technologies.

In ***Slovenia***[23] the priorities of the S&T policy (2001-2002) are defined in the Budget Memorandum and the main instruments of the policy are:

- (co-)financing of basic and applied research projects / programmes;
- public research institutions (co-financing of fixed cost of public research institutions and research institutions within both universities);
- international co-operation in the field of science and research (co-financing of bilateral and multilateral research projects, international commitments, international promotion of Slovenian science);
- Young Researchers Programme (financing of young researchers);
- (co-)financing of research infrastructure (research equipment, instrumental centres, scientific information and communications);
- financing of expert system (evaluations, reviews etc.).

[22] Based on Havas (1999) and additional data provided by Lajos Nyiri and Bálint Dömölki - Panel members
[23] Boris Pukl, Panel member

Monitoring and evaluation of S&T performance

The regular monitoring of the research, development and innovation (RDI) system performance and the inventory of available resources is a foundation to the determining S&T objectives and to the proper functioning of the whole system. Monitoring systems are essential to achieve and understand the performance of RDI systems and for adjusting policies. In many candidate countries there are not reliable data on input (funding) and outputs (economic performance) of the RDI systems.

Monitoring and evaluation of S&T in candidate countries is not systematically organised in comparison to EU countries and actions are needed to strengthen this aspect. Some countries are starting considering monitoring systems as important tools for better S&T performance (see Box 3).

In general, however, candidate countries depend on external consultancy to monitor and evaluate their S&T programmes and outcomes. In addition, monitoring is frequently done on an ad hoc basis at project-level. There is the need to create an internal capacity in these countries in order to have continuously available monitoring and evaluation of the public R&D. The lack of monitoring means that in is unknown how the BERD indicator is developing. Evaluation systems are required for the development and continuous improvement of policy and the adjustment of policy tools.

There is the need to implement a system in all candidate countries that uses more systematically indicators to assess the performance of R&D and models for quality evaluation of research outcomes. Benchmarking should be organised considering European average level, but also other countries like United States, and non-European countries.

Box 3: A monitoring system to follow and evaluate the actions in the National Strategy for Technology Development and Innovation

A monitoring system to follow and evaluate the action in the National Strategy for Technology Development and Innovation could have the following objectives:

- To define benchmarks which will provide realistic targets for the implementation of the Strategy
- To develop a set of indicators against which progress on implementation of the Strategy will be measured
- To choose a method for collecting information on the agreed indicators

The implementation of the National Strategy for Technology Development and Innovation should lead to beneficial results for the country as a whole in terms of improvement of the national research and innovation capacity and performance. A set of indicators will be developed against which the innovation performance of the country will be measured. A possible set of indicators might include physical indicators, impact indicators, performance indicators and financial indicators:

- **physical indicators** to measure data such as infrastructure provision
- **impact indicators** to measure the impact of activities in support of technology development and innovation
- **performance indicators** to measure the results obtained in terms of objectives
- **financial indicators** to measure the amount of investments to improve the national innovation system

(Zoya Damyanova, Panel member)

Future directions for S&T policy

A clear challenge for the coming years is to rationalise and co-ordinate diverse initiatives currently taken by various ministries to promote industrial R&D, innovation and technological development. This could be supported by the professionalisation of S&T monitoring and evaluation in the form of **innovation policy units**. They would be responsible to assess the performance of current instruments and structures promoting innovation or technological development, using tools such as:

- evaluation and monitoring systems – to measure the effects of R&D investments, to enable policy makers to monitor industrial R&D and their use of public R&D
- unified set of indicators
- tools/ instruments used in PACs for elaboration/ implementation of priorities, development of knowledge infrastructure, learning capabilities
- benchmarking, best practice, impact assessment, transparency of criteria, audit

But the fundamental issue is the need for co-operation of the widest possible group of stakeholders (within and among sectors and regions) in preparing long-term innovation strategies and the introduction of various policy measures and instruments. A focus on nurturing foresight activities is a move in this direction. And, although the first steps to carry out prospective studies (in Hungary, Poland, Czech Republic) have been taken in PACs, there is still a need for wide acceptance in PACs of the role of foresight to systematise the debate at national level on future prospects and desires related to socio-economic and technological evolution in medium and long terms.

Such developments are particularly promising in that they address actors outside the confines of scientific interests and expert groups. In the most extended cases they avail themselves of a complete range of horizontal communication possibilities. For instance, there is increasing on-line access to local and national information systems in the area of S&T, to the results of research projects and programmes, to science museums, to science festivals and to citizens' juries. All such channels could contribute to the transparency of the research activities and facilitate the communications of all actors involved and improve the performance of the whole RDI system.

Such openness provides the basis for a much broader look at science, in particular focusing on cultural identity and democratisation of science. The development of PAC governance systems takes place at a time when there is a recognised need for a change of image of S&T and the perception of science in society has been also stressed, in particular the popularisation of science between people and how it could help them. Such approaches should eventually allow a more balanced and legitimate system of priority setting.

The present trends in PACs suggest that efforts are needed to confine public and private S&T ambitions to what is really achievable. The gap has to be closed between political rhetoric and action, effort and outcomes. Unfortunately there are often big gaps between national S&T targets and the level of resources provided. These gaps arise as a result of a combination of too many competing calls on political agendas, administrative shortfalls and genuine lack of resources, all of which point to systemic and institutional problems of one sort or another. Proper policy co-ordination and implementation, greater transparency of S&T governance and more effective monitoring and evaluation can help to improve the efficiency of actions. On the other hand, there is a need for more holistic approach on R&D – amounts spent on R&D are not as important as the kind of research on the way.

The measures already undertaken for financing and promoting research and innovation outline the common perception in PACs of the future importance of S&T in the society, for growth and employment. However, there are some doubts related to the efficiency of the financial instruments and mechanisms used and their real contribution to S&T development. A challenge for PACs, therefore, is to establish an effective and transparent distribution mechanism of the limited financial resources available for research, according to national interests and priorities. Better investments in research require fair and open competition for funding based on relevance and excellence using objective and transparent criteria.

At the same time it is essential to consider how to preserve the fundamental research traditions while pushing competitive funding schemes. In PACs, where an active national and regional S&T policy is absent, and the state support for research is limited, the excellence in science and technology will increasingly rely upon competitive application for funding by international sources (inside consortia or as part of international projects). The participation in international programmes allows prominent researchers to obtain the necessary technology and financial resources, as well as to increase their scientific knowledge and experience. Also, a Europe-wide dialogue with the private sector[24], in particular multinationals that are investing in PACs, might help to build the industrial component of research in candidate countries.

[24] Bálint Dömölki, Panel Member

Chapter 2
Knowledge institutions and capacities

2.1 Towards a new knowledge infrastructure

Introduction

For pre-accession countries the transition to a knowledge-based economy and society is essential for their full integration into the 'European' economic area and society. The need for higher economic growth, competitiveness and sustainable development puts a special emphasis on the knowledge infrastructure in these countries - the aim of this chapter is to outline the tasks related to its future development. We concentrate on the following:

- system building and institutional interactions
- knowledge and technology diffusion
- personnel mobility as the main source of tacit knowledge dissemination.

The knowledge-infrastructure analysis in the first section focuses on the main building blocks of the Research, Development and Innovation (RDI) system – research units (research institutes, public laboratories), universities (and other educational and training institutions), enterprises (branch and industrial R&D) and intermediaries (bridging institutions, technology transfer organisations, patent offices), and the links between them. The building of a more effective and efficient knowledge infrastructure in candidate countries is seen in terms of the requirements for:

- a coherent R&D and innovation system;
- strengthened partnerships between research, universities and industry;
- new infrastructure and intermediaries to facilitate technology transfer;
- emergence of relevant knowledge intensive services; and
- increased openness to international networking.

In analysing recent knowledge infrastructure developments in candidate countries, this section seeks signs of emerging models of research in PACs and of future knowledge institutions.

The system of research and innovation

In the past, the R&D systems in CEECs were characterised by three types of institutions – academies of sciences, institutions for higher education, and industrial branch research institutes. During the transition period, different countries followed different restructuring strategies (Box 4), though with almost all branch institutes being heavily affected and a large number of them being closed. The process of transformation has followed three phases[25]:

- dissolution and fragmentation of the old S&T systems;
- restructuring, consolidation of institutions, emergence of new organisations;
- building of a new innovation system through integration and networking.

[25] Meske (2000)

Box 4: Approaches for the restructuring of the R&D system

The patterns of restructuring of the science base have been quite different from place to place[26]. Candidate countries focused at different stages of the transition on organisational, functional and financial aspects of the R&D system and often introduced temporary incompatible changes[27]. A few countries engaged in an active restructuring, such as Estonia and Latvia with attempts to ease the process of change with legislative measures, co-funding, innovation policies, etc. Some CEECs, such as the Czech Republic, allowed industrial research to suffer the shock of a rapid transition to a private sector model. Probably the most common approach, such as in Poland, Romania, Lithuania and Bulgaria, was to let the research institutes struggle along with reduced public funding and state contracts but no active support to restructure.

The ***Latvian*** approach[28] in restructuring R&D is based on the integration of the national research potential into universities with the aim of modernising the universities and strengthening their research capacity. Research centres of national significance have been established, selected using the following criteria:

- high international recognition;
- consistency with national research priorities;
- well developed international collaboration in research and training;
- advanced and innovative performance.

In the ***Czech Republic***, in comparison, no structural policy was carried out at a microeconomic level within the R&D system.[29] The government had withdrawn financial support from the majority of industrial R&D institutes at an early stage in the transition process and during the privatisation they were treated as 'normal' production enterprises. This shock without therapy led to the conversion of the institutes R&D activities into production and services. Business is by far the largest contributor and the largest recipient of research and development funding, employing more than the half of all researchers.

In ***Poland*** during the transformation period a gradual restructuring policy was followed, changing the public funding principles and ranking of institutes. However, the R&D system in general has retained the main features and structures of the previous system and a large number of R&D institutes still receive subsidies.[30]

Due to the lack of an active restructuring policy in ***Lithuania***, some industry-oriented research institutes moved from basic to applied research and created companies in their area of specialisation. At present, it is considered that industrial R&D in Lithuania is substantial and directed to innovation, based mainly on own R&D resources of companies, using human resources of former research institutes[31].

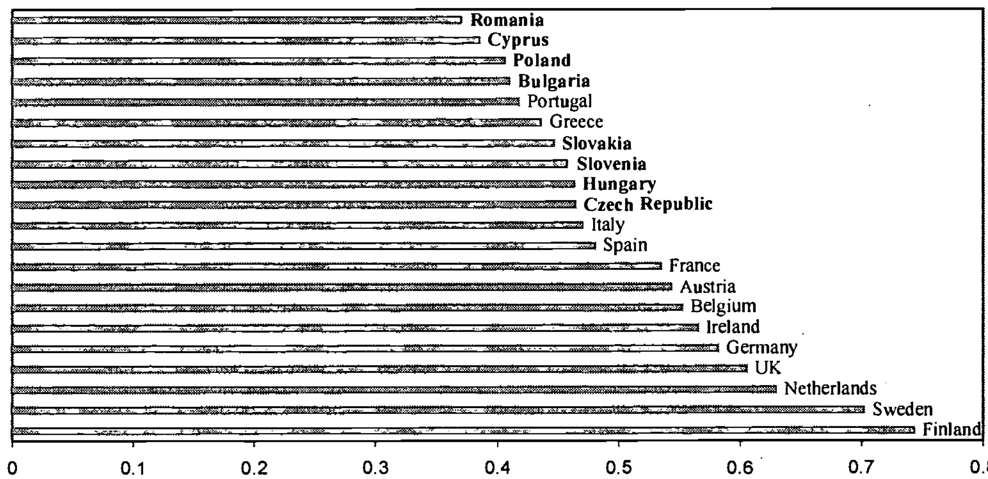
National circumstances differ, but most of the candidate countries have completed the first two phases with the third phase still lying ahead. Although the S&T development in the Mediterranean countries has followed a different path, these countries are also focusing on the establishment of a coherent RDI system and the use of the potential of technology and innovation for economic growth and sustainable development.

Recent data giving an aggregate comparison between some PACs and current EU members paint a positive picture, suggesting that the PACs have the potential to sustain high-level research systems, at least on a par with several current EU Member States (Figure 4).[32] The same report gives further figures on investment in technology creation

[26] see Meske, (2000); Dyker et al. (1999)
[27] Radosevic (1999)
[28] Sylins (1999)
[29] European Commission DG Enterprise (2001)
[30] European Trend chart of innovation, Country reports: Poland (2000), http://trendchart.cordis.lu
[31] European Commission DG Research (1999)
[32] The UNDP's technology achievement index aims to capture how well a country is creating and diffusing technology and building a human skill base - reflecting its capacity to participate in technological innovations of the network age. This index is a composite of four dimensions including technology creation (patents granted to residents; receipts of royalties & license fees),

where data for the PACs are compared with three Member States (Italy, Greece and Portugal) and the average for high-income OECD members.[33] This shows the relatively low levels of R&D investments even if in some cases it surpasses some current EU Member States. However, while such data certainly do give grounds for hope, it would be premature to assume that much of the work of reconstructing the knowledge infrastructure has been done.

Figure 4: Comparison of PAC and EU States' Technology Achievement



The main problems relate now in all PACs to the fragmentation of the RDI system, based on the lack of co-ordination and interaction between the main actors, and thus its inefficiency[34]. As pointed out in the first chapter, science and research, and technology and innovation are not considered in their integrity. Only in few countries like Romania and Turkey a separate public body has responsibilities for both, innovation and research. Furthermore, the fast changes during the last decade do not facilitate the integration of all actors of the RDI system. Therefore, a closer look is needed to outline the challenges which relate to:

- the interactions between research institutes and enterprises
- the links between universities and industry
- the emergence of bridging organisations and new players.

diffusion of recent innovations (internet hosts; high & medium tech. exports), diffusion of old innovations (telephones, electricity consumption) and human skills (years of schooling; output level of skills & qualification, tertiary professional and scientific education enrolment and graduates' ratio). UNDP (2001)

[33] The relatively high number of scientists and engineers in R&D does not appear to be consistent with the acknowledged collapse of applied research, but then it may well be that many of these high numbers reflect scientists and engineers still in academic positions in Universities and academies of science.

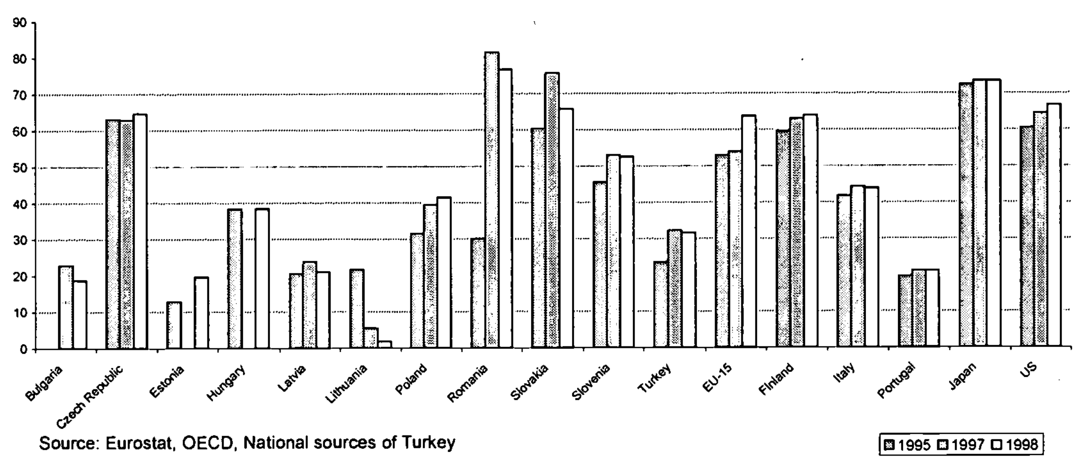
[34] European Commission DG Research (1999)

Research-industry interactions

Breaking with the state control of the past, R&D institutions in CEECs are considered to be now self-governing and autonomous, open to international collaboration. However, the decline of financial support by the state and the inability to attract other funding confront most of them with growing problems of preserving their research capabilities and carrying out world-class research. The passive policy of some governments towards restructuring of the academic institutes has the transitory advantage of preserving some jobs. But, the stagnation of research capabilities might have much bigger long-term consequences.

Although widely discussed in policy documents, the need for enterprises to establish closer co-operation with research units and to increase their research expenditure, practical results are still low. Business investment in research is generally lower than the EU15 (Figure 5). Some remarkable exceptions include Romania, Slovenia, Czech Republic and Slovakia where industrial R&D expenditure is comparable to the level in EU members. But elsewhere, the industrial contribution seems very low. However, a question exists as to whether the statistical data really reflect the situation, and whether the companies, in particular SMEs, are motivated to report any costs made for research rather than just as product costs[35]. The low quality of data for industrial research and innovation makes it very difficult to assess the situation as regards the financing of industrial innovation and therefore to identify appropriate steps to improve the situation. The different pace of privatisation also needs to be taken into account and the level of contribution of state-owned companies to research.

Figure 5: GERD financed by industry (in %)



Source: Eurostat, OECD, National sources of Turkey

The history of central planning in CEECs and the reliance on public funding sources have inhibited the growth of business-research linkages, and this contributes to the difficulties that public research institutes face today. In Poland, for example, industrial research has played only a minor role in the institutes of the Polish Academy of Sciences. These have focused mainly on scientific collaboration with other research institutes in basic science. Specialised R&D units in Poland have relatively better interactions with industry, mainly in technology and product development, but even here passivity rules[36].

[35] Bálint Dömölki, Panel Member
[36] Jasinski (1997)

Branch research institutes had stronger and more differentiated interactions with industry in the past. But with the cutting of state support and drying up of industrial funding during the restructuring, they have had severe difficulties to retain professional equipment and their best staff. Their inability to finance longer-term research and their present focus on short-term services, as well as the lack of consultation with industry on choosing industry relevant research topics, might further limit the establishment of closer collaboration.

The insufficient industry-research links relate also to a lack of demand by industry for the services that domestic research units can offer. Independent major companies frequently disappear after privatisation and become either subsidiaries of multinational corporations or their specialised suppliers or service providers, which little exploit local research expertise. On the other hand, competition is driving domestic enterprises to apply advanced research results. Despite the high costs of the services of private commercial firms and foreign consultants, domestic companies in Hungary, for example, rely on collaboration with foreign laboratories for quality upgrading activities, product development and testing[37]. There are some grounds for hope. The traditional collaboration with domestic partners may be re-established if they overcome the problems of understanding the real industrial needs and improve the quality of their services. Companies appreciate the value of individual researchers and prefer to hire their services on part-time basis, rather than to establish co-operation agreements with R&D institutes[38]. Some domestic enterprises continue to rely on their own research capacities in engineering, product development and design.

University-industry links

Due to the role of the universities as educational and training centres preparing the future high-skilled workforce, the impact of transition has been not as acute as in the research units. The new framework for education in CEECs has facilitated the establishment of private universities, many of them specialised in domains relevant to economic needs. Moreover, the development of more open and internationally integrated higher education has been initiated (see Chapter 3).

Economic expansion has fostered the re-establishment of industry-university links, focused on training high-skilled specialists and managers. In most PACs the interaction between industry and higher education establishments has been extended from what was originally limited to sponsorship to closer collaboration in developing joint courses and programmes, training materials, on-the-job-training of students, as well as carrying out research. These types of initiatives are creating a positive feedback, in that industries are beginning to sponsor the education of future employees. Moreover, the on-going collaboration in setting-up laboratories and technology centres at universities is likely to continue and deepen industry-university interactions also in research (Box 5).

Universities have developed as important centres for both, research and education. They seem to be a preferred partner for the industry for carrying out contract research. In particular, some technical universities (e.g. in Hungary, Bulgaria, Estonia) have long traditions in this area and are on the way to re-establish and widen this type of activity. In Hungary different foreign companies (e.g. Ericsson,

[37] Romijn (1998)
[38] Howell et al. (2000)

Nokia, Sony, Knorr-Bremse) are involved in joined activities in research labs at the Budapest Technical University in telecommunications, electronics and automotive engineering.

Box 5: University centre of research

In Estonia the integration of research at university has significantly strengthened the research capacities and intellectual resources of the universities. The *Tallinn Technical University (TTU)* has combined bottom-up and top-down approaches in extending its industry relations.

For several years now TTU has carried out contract research on behalf of large infrastructure companies in the areas of electricity production and distribution and oil shale mining, as well as with manufacturing companies in the fields of signal processing, electrical equipment and power electronics, automotive industry, etc. In the field of telecommunication, TTU has started long-term co-operation with the Estonian Mobile Telephone Company and Ericsson Eesti AS., launching a testing and training laboratory. The co-operation of TTU in chemical technologies with a manufacturer of rare earth metals (AS Silmet Grupp) includes mainly technical consultation and technical information exchange, but is expected to be extended to contract research in coming years.

In addition to contracts with local companies TTU performs contract research for foreign companies as well. Current contracts include large multinational concerns (like Nokia), but also small companies (Fincitec in Finland) and ranges from sectors such as chemical technologies, material technologies to information technologies and telecommunications.

Considering the important role of competence centres and innovation support structures for knowledge transfer, a Tallinn Technical University Innovation Centre Foundation was founded in 1998 to connect R&D data of the TTU with technological needs of industrial enterprises.

The range of activities of TTU will be extended with the establishment of a graduate school. This will contribute to the concentration of the existing resources and the improvement of research training.

(Rein Küttner, Panel member)

Universities have formed their own centres for co-operation with industry. The flexibility of university management and their self-governance facilitate the establishment of spin-off firms for commercialisation of research results. The involvement of some universities[39] in shared activities with the newly created spin-off firms - e.g. the participation of professors in business activities and the engagement of students as trainees and workers - is fostering research-industry relations, as well as the further development of applied research in PACs.

Building bridges

At institutional level, one of the obvious challenges for building a coherent RDI system relates to the linking of R&D institutes, universities and industry. The teaching activities of researchers, both at universities and at research units, the involvement of professors in research projects, collaboration in scientific events and programmes are part of the new type of co-operation pattern in the RDI system. However, these interactions are mainly at individual level without establishing tighter institutional links (except where the research institutions have been integrated into universities following an active R&D restructuring policy).

[39] e.g. Tartu University and Tallinn Technical University in Estonia, Warsaw Technical University

The need for building bridges between research and industry has led during the past few years to the emergence of a range of new institutional structures (state or private supported bridging elements) in most pre-accession countries:

- infrastructure units (parks, incubators);
- organisations for innovation support of a 'consultant' character (innovation relay centres, Euro-info centres, technological centres, specialised consulting companies, foundations).

Set up by government bodies, researchers or non-governmental organisations (NGOs), the new intermediaries represent an enormous concerted attempt to establish new models of co-operation between business and research. The activities of the intermediaries cover a wide range of knowledge-intensive services – provision of information and advice, ICT support, organisation of training programmes, assistance for finding partners and joint projects, dissemination of advanced technologies, channelling innovative ideas & inventions and support in the protection of intellectual property. However, the development of intermediaries is heavily dependent on existing financial resources. After the end of the initial public or international funding, a number of them face the dilemma how to survive in the market-driven environment.

Box 6: Intermeddiary to support applied research

The *Technology Development Foundation of Turkey*[40] has been established by the collaboration of private and public sectors in 1991. The assets of the Foundation are donated by the founders and some obtained through the Loan Agreement between Word Bank and Turkey. In the management of the Foundation senior representatives of the Treasury and Foreign Trade and the Scientific and Technical Research Council of Turkey (TUBITAK) are involved. The aims of the Foundation are:

- to encourage Turkish industry to increase in real terms its investments in research and development and to carry out all activities in accordance with the requirements.
- to provide funds and expertise supportive of industrial technology projects to enhance technology and technological infrastructure.
- to identify technological research areas and carry out research and projects in such areas alone or by contract to bridge the technology gap between Turkey and other nations and strengthening Turkey's position in some global trade sectors.
- to strength the ties between Turkish industry and higher education institutions, TUBITAK and other public and private research organizations.

(Dilek Cetindamar, Panel Member)

A growing number of new players, e.g. foundations, industrial associations, chambers of commerce, NGOs, are supporting research and innovation in PACs (Box 6). Most of them have an active intermediary role between the institutions governing the RDI system, the small and large companies and the research units. Some are going also further – providing knowledge-intensive services and/or trying to solve applied research problems, and, in particular, focusing on the socio-economic demands for research. Through their efforts at networking, these actors are quickly able to build research teams on demand. The flexibility for building multidisciplinary teams, involving prominent researchers, engineers, lawyers, entrepreneurs, etc. in a particular project, maximises their chances of success in the dynamic changing environment and in the competition for research and innovation funding.

[40] see also http://www.ttgv.org.tr/eng/eng_main.html

The extension and building of further research capacities in many candidate countries occurs via the establishment of centres of excellence or centres of competence, in some cases at universities, in others at strong research institutes or newly established bodies. As discussed in the first chapter, international co-operation within the EU Fifth framework programme has fostered the emergence of a number of centres of excellence in all candidate countries. The European Research Area provides also for development of centres of excellence at national level and positioning them within a single European network - fostering high-level research and more efficient deployment of the limited human and financial resources for obtaining new technological solutions and scientific achievements. At national level, the emerging centres rely on existing and potential capacity. The establishment of a pool of R&D competence to respond to the needs of research by industry, as well as the support of the scientific community, industry and the state to these structures is facilitating their growth as attraction poles for research in the respective areas. Of particular importance is their strong international collaboration with researchers in the same area for establishing pan-European excellence in research.

Future models of research

Concerted actions of all stakeholders in PACs, e.g. policy makers, industrialists, researchers, professors, NGOs, are needed to build a coherent RDI system in which the institutional base is densely interconnected. In this period of structural change there is a widely accepted need to create a favourable environment and foster effective communication between the major actors in the system. Bridging organisations are part of the solution, but they do not substitute the need for intra-organisational restructuring. Bridging functions are most likely to work as complementary functions to restructured enterprises, universities, R&D service companies. The survival of bridging organisations will require them to develop a sustainable business model, perhaps as SMEs, with their own specific in-house capabilities, including knowledge transfer capabilities.[41]

At this stage, when old and new structures exist in parallel, it is still uncertain what model for the development of research candidate countries will follow. There are real opportunities for PACs to leapfrog ahead towards the setting up of new types of research interactions, more appropriate for the demands of the knowledge society. If we consider the present trends, some important models for research could be assumed for candidate countries:

1. Economic modernisation is driving new **industry-university** links focused on building the future knowledgeable workforce. This provides an entry point for university-based laboratories and technology centres engaged in industrial support for applied research. Universities also may attract industrial researchers as part-time professors. Personal links between supervisors and graduate researchers who then go on to work in industry will also help. Finally, the good facilities in some universities, in particular high-speed Internet and modernised technology basis of laboratories, are likely to support their claim as to be centres of research in the future.

[41] Dyker et al (1999)

2. **Centres of excellence** are emerging outside of the universities characterised by strong research teams, young researchers, dynamic professors and close links to industrialists. These centres of excellence provide a creative environment for basic research and generation of new ideas and innovation. Most of them have been established within EU programmes for research and therefore are dependent on international funding and the question is to what extent they can be developed further as centres of national strategic value. Recognition of this possibility by local public and private stakeholders is especially important for this prospect to pan out.

3. **International and regional networking** is increasingly becoming an essential means of staying abreast of research developments and acquiring expertise. Support for common projects with foreign partners can contribute to profiling areas of excellence and competence and could lead to the establishment of regional multinational research centres with international teams actually based in PAC laboratories.

2.2 Technology transfer and innovation

Introduction

Knowledge is a driving force of economic growth and societal development - but only when it is successfully put into practical application. Thus innovation has become an important policy theme for Europe from the Green Paper on Innovation[42] to the Lisbon summit of the European Council (March 2000), which set the goal Europe to become "the most competitive and dynamic knowledge-based economy."

In the process of developing market economy and meeting the objectives of the accession to the EU, innovation and technology transfer are likewise essential for industrial competitiveness and market growth in PACs. To catch-up rapidly PACs have to establish frameworks conducive to innovation, support innovative firms and foster a culture of entrepreneurship. While the previous section has focused predominantly on the institutions within the knowledge infrastructure and the links between them, the aim of this section is to outline the main mechanisms for technology transfer and innovation in candidate countries.

Knowledge and technology flows

The process of economic transformation in CEECs had many consequences for domestic enterprises. The opening of the market to competition, privatisation, the collapse of the traditional export market in Eastern Europe and the disappearance of state support, have constituted a dramatic shift in the business environment. The increased competition after the liberalisation, along with the disintegration of the state distribution and marketing network and the decline of customer demand, have caused a number of domestic companies to lose their place in the market - many have gone bankrupt. The survival of companies has been highly dependent on the speed of change in their productivity and competitiveness. The access to new

[42] COM(95)688 final

technologies followed by fast acquisition and application has been the most successful strategy for enterprises.

The main mechanisms for technology transfer in PACs are mostly indirect such as:

- inward transfer of 'hard' (product, process) or 'soft' (management) technology, mainly by foreign direct investment;
- integration of local firms into the international production chain by subcontracting, outsourced assembly processes, provision of distribution services, reverse engineering of products and/or customised production and design;
- co-operative industrial alliances with foreign partners and learning-by-trading.

Direct technology transfer is limited to interchange of personnel (spin-offs from research units or researcher-led start-ups) and is rather small scale. What seem to be lacking are effective stimulants to attract significant levels of corporate investment in R&D.

Inward technology transfer

Foreign direct investment (FDI) offers the prospect of significant supplements to weak domestic investments and is considered a key vehicle for technology transfer. The foreign ownership of many companies in PACs has allowed them easy access to foreign finance and markets, and to modern technology as well. Even where a minimal transfer of 'hard' technology (product, process) has been carried out, FDI has led to transfer of 'soft' (management) technology. In both cases the transfer of technology has been facilitated by the availability of knowledgeable individuals to adapt it to the local circumstances. However, the dominating opinion in many circles, that the availability of cheap highly skilled labour in PACs is attracting foreign investors, has been disputed in a recent EBRD study[43]. Actually, the main attractions have been access to the host market and favourable regulatory and tax treatment. For this reason, in 1997 more than 85% of EU FDI in the candidate countries were concentrated in 4 countries – Hungary, Czech Republic, Poland and Turkey. However, recent Eurostat data[44] show that Hungary and the Czech Republic are characterised by relatively lower rates of growth of EU investments, while in Romania, Poland, Bulgaria and in the Baltic countries a significant expansion has been noted.

FDI had serious implications for the rest of the domestic enterprises – without resources and skilled personnel their competitiveness has been very limited, leading to a 'dual economy' in candidate countries. For the domestic manufacturers the import of foreign machines and equipment has been the best strategy to keep their market niche. Even if enterprises are able to maintain their market position and carry out innovation, high cost and time pressure has prompted them to prefer to buy turnkey technology rather than to develop domestic solutions[45]. However, due to the insufficient resources in most cases, technology upgrading has been limited to the introduction of some basic machinery to allow them to improve quality, meet environmental standards and produce a limited range of contracted products.

The transfer of embodied technology from abroad and FDI alike make little use of local R&D capacity and capability (Box 7). Nevertheless, FDI has played an

[43] EBRD, Transition report 2000
[44] Eurostat (2000a)
[45] Mueller et al. (2000)

essential role in the upgrading of human and capital resources in CEECs. Foreign investors have created better employment opportunities and have contributed to upgrading the skills of the best-trained specialists and the overall improvement of the technological knowledge of the personnel. It is not surprising, therefore, that the labour productivity of foreign-owned enterprises varied in 1998 from 150% (in Estonia) to almost 300% (in Hungary) of the productivity in domestic companies[46].

Box 7: FDI and local R&D

After the investment by leading foreign companies (and the following change of ownership) in big telecommunications manufacturers in Hungary, Poland and the Czech Republic, local knowledge has been used in modernisation and in the localisation of imported technologies. To assist the transfer, parent companies have provided technological assets such as R&D personal, know-how, licences and patents. Apart from advanced technology, the subsidiaries have received complementary financial assets and to a lesser extent marketing skills support. The main tasks of the R&D units of the domestic company have been related to software development and adaptation of the equipment to the local network.[47]

In the car and the textile industry foreign investors have established manufacturing plants and the R&D function has been shifted to their technology centres abroad. Previous R&D departments have been closed. The main emphasis of the foreign owners has been to upgrade and improve quality of production and introduce new technologies rather than to focus on domestic R&D or design functions.[48]

Finnish electronics firm Elcoteq, that assembles handsets for Nokia and Ericsson, has opened factories in Estonia. However, no Estonian R&D have been used. Moreover, due to the shortages of local computer specialists, Scandinavian companies are using talented Estonians abroad instead of using the possibility for outsourcing some tasks[49].

Networking of enterprises

In the past decade, communication technologies - especially the Internet - have fostered new business configurations and world-wide production chains. Production processes continue to become internationalised with the modularisation of production tasks between more and less advanced countries. These trends provide new opportunities for technology transfer in candidate countries and technological catching-up, but often within a narrow range of production activities. Subcontracting to foreign companies has become for many domestic manufacturers the only feasible survival strategy, and is technologically less demanding than the development of their own products. After losing the large Soviet markets and faced with the increasing competition of foreign firms, companies from CEECs in many sectors have been integrated into the product life-cycle through subcontracting or outsourcing, assembly, distribution, reverse engineering or at best customising product design (Table 6).

[46] European Commission DG Enterprise (2001)
[47] Sadowski (2000)
[48] Romijn (1998)
[49] European Trend chart on innovation, Country reports: Estonia (2000), http://trendchart.cordis.lu

Table 6: Sectoral specificity and prevailing co-ordination mode

industry	fragmentation	scale effect	co-ordination mode
telecom equipment	low	assembly	merger&acquisition / joint venture
automotive parts	high	assembly	contractual/ sub-contractual/ joint ventures
computers	high	components	contractual / outsourcing
software	high	components	contractual / outsourcing
audio & video	high	final product	contractual/ sub-contractual
machine tools	high	final product	contractual/ sub-contractual

Source: Kubielas&Yegorov (2000)

For SMEs in PACs, as in many countries, networking has become an effective means of innovation in its own right. Interactions with other firms and the opportunities for knowledge sharing and exchange (via obtaining patents, licenses, or purchasing of equipment) have allowed companies to be more specialised and to focus on their core competencies. For complementary knowledge and know-how, they increasingly rely on interaction with other companies.

In the absence of FDI, the technology transfer and know-how crucial for the development of leading domestic computer manufacturers have been transferred through non-equity co-operation agreements with foreign partners. A process of learning-by-trading and building strategic co-operative alliances is becoming the main channel for technology transfer for a number of hardware and software companies in CEECs. Although hardware companies have concentrated on the less knowledge intensive computer assembly functions they have often been able to attain large market shares. Moreover, many domestic software companies have exploited the local knowledge of customers as a competitive asset and are often ahead of foreign companies in the local market that require local know-how such as software for company management, financial accounting or banking. [50]

Innovation performance and demand by industry

The lack of data on the innovation performance of the enterprises in candidate countries makes it difficult to draw any general conclusions. Recent Eurostat statistics for four countries[51] show that large enterprises in PACs continue to have higher expenditures for R&D and innovation than the SMEs, (consistent with the EU). Shares of innovative enterprises in Slovenia (33%), Poland (29%) and Romania (28%) are similar to Spain (29%), but very low in comparison to Germany (69%) or Ireland (73%)[52]. Generally, the share of research and engineering activities in CEECs is more than two times smaller than in the EU. Enterprises in Poland and Romania tend to invest in acquisition of machinery and equipment, while in Slovenia the emphasis is on in-house research. Polish companies also make significant investments in industrial design and production preparation, while in Slovenia second place goes to marketing strategies. All companies show very low investment in training.

[50] see Kubielas et al.(2000)
[51] Eurostat (2000c)
[52] Radosevic (2001)

Limited financial resources and low revenues prevent domestic companies from funding their own research or from accessing other R&D results. Turkish pharmaceutical companies, for example, have low R&D capacities due to the small production volumes and the price regulation in the sector. Their R&D activities comprise mainly research related to licenses or production problems. Any investment in long-term research in developing new biotechnology applications for pharmaceutical products, even though they have a big potential, has been limited[53].

The Eurostat survey data suggest that demand for innovation has different grounds and is disproportionately spread over economic sectors in candidate countries. The majority of innovative enterprises focus on product and process innovations at the same time. While undertaking innovation, domestic companies in PACs aim primarily at improving their competitiveness and increasing market share. For meeting this target they focus often on product quality and diversification through in-house research and using the services of testing and certification companies for quality assurance. To a less extend the reduction of labour costs, materials and energy consumption influences the innovation activities of enterprises. The requirements for environmental protection are also inciting innovation, and the introduction of new environmentally friendly technologies or other measures to reduce the pollution.

The production of goods and services is becoming more knowledge-intensive and a variety of new services employ highly qualified labour. Economic growth and the demand for knowledge-intensive services have influenced self-employment. A lot of the newly established firms in the service sector are engaged in engineering or consulting. Although quantitatively small, these entrepreneurial firms are important catalysts of innovation and represent an important model of the human dimension of technology transfer. A large number of the entrepreneurial firms are spin-offs from former research units or universities, oriented towards the marketing of their own products. Many researchers, mainly in the area of applied research, have founded own companies and exploit the results of their R&D work.[54]

Action lines for innovation

Candidate countries differ in the policy prioritisation of innovation action lines, and in the practical measures undertaken (see Table A3 in Annex III). Cyprus, Lithuania and Hungary have introduced a wide range of practical measures covering all priority areas of the Innovation Action Plan[55], while Estonia, Slovenia, Poland and Romania, put higher political priorities on education and awareness-raising activities. A third group of countries (Latvia, Slovakia and the Czech Republic) emphasises applied research and strengthening the ability of enterprises to absorb new technologies. Latvia puts also high priority on fostering innovation culture of enterprises and introducing measures for education and training.

Generally, the main problems are related to the implementation of these measures and their real value for the enterprises. The lack of reliable data on innovation performance of enterprises, means that policy decisions are more influenced by the EU negotiation

[53] BAŞAĞA et al. (2000)
[54] Meske (2000)
[55] COM(96)589 final

requirements than either the needs of domestic enterprises or national and regional development priorities. As the assessment in the EBRD Transition report suggests, the level of the most advanced candidate countries is close to the level required for development of private enterprises without major obstacles. However, the process of setting-up of legal and administrative environments for innovation is still not finished in PACs. Although the governments have launched a range of initiatives to foster innovation and the importance of business networking has been recognised in many PACs, only a few have introduced real practical measures to encourage foreign investors to use domestic suppliers or have provided a favourable tax relief (see Box 8). Moreover, intellectual property rights (IPRs) are not considered as a key constraint on innovation in PACs and few activities have been carried out to establish IPR support services in universities and to raise the awareness of innovative SMEs to protect know-how.[56]

Box 8: Fostering industrial research and innovation

Most candidate countries have introduced some *tax initiatives* for general improvement of business climate and investment. Only Hungary and Poland from the first group of PACs[57] had a special tax deduction for industrial R&D investments. However, in Poland the tax relief for R&D was discontinued in 2000 as part of the overall tax reform process. In Cyprus a proposal for a 10 years tax holiday on profits derived from the production of new products is being discussed by the government. In the Czech Republic tax iniciatives have been introduced for companies that plan expansion, foreseeing up to 10 years tax holiday on technology imports.

Hungary and the Czech Republic appear as pioneers in introducing policy instruments for support of the development of business networks and promoting of supply chains between large (foreign owned) firms and SMEs. In Hungary within the INTEGRATOR scheme, launched in 1999, a vertical network of a large firm and its suppliers is entitled to a grant to reinforce the linkages to its members. The objective of this policy scheme is to increase the capacity of domestic companies to become suppliers to multinationals for a longer term, as well as to foster domestic firms to upgrade their technological and managerial abilities and practices.

Similarly, a government subsidy for subcontracting relationships has been implemented in *the Czech Republic*. The established supply-chain network of VW/SKODA is considered to be a successful case. According to its obligation in the contract with the state to address domestic suppliers, the company has developed a demanding scheme for improvement of their product quality, observation of delivery terms and costs reduction. The result was that a number of domestic firms have gained the status of reliable component suppliers and have been able to extend their production through contracts with other foreign manufacturers.

(Source: European Commission DG Enterprise, 2001)

Regional disparities and the scarcity of S&T factors in regional development plans also cause major concern. The scope for local supply and demand for S&T and assessments of regional strengths and weaknesses in R&D are mostly unknown, while technology transfer and innovation is to be encouraged. The R&D system mainly centres on capital cities, with weak and slow regional innovation performance. Institutional decentralisation has been attempted in some candidate countries. Hungary is considered the most advanced in this respect, but more diversity has been achieved in Poland, where some efforts have been made to set up regional institutions for technology transfer and a network of (regional) 'Voivodship Clubs'[58]. Similarly, in Bulgaria, the Agency for SMEs in collaboration with BARDA (Bulgarian Association of Regional Development Agents) has established an institutional framework of more than 20 Regional Development Agencies covering many administrative districts and operating at least one business/ agri-

[56] European Commission DG Enterprise (2001)
[57] Cyprus, Czech Republic, Estonia, Hungary, Poland, Slovenia
[58] European Commission DG Research (1999)

business centre or business incubator and Internet bureau. SMEs and regional development are key debate issues also in Romania, in particular the introduction of effective measures to promote local initiatives, an active partnership between the local authorities, business and research and their co-operation with other European countries in order to promote technological innovation.

The involvement of domestic enterprises in a number of activities within EU programmes[59] has facilitated regional and bilateral co-operation in innovation and research (e.g. within wide European networks of Euro Info Centres, Innovation Relay Centres, Business and Innovation Centres, Centres of Excellence). For example, PHARE and INCO-Copernicus have provided support for product development, as well as foreign consultancy assistance for restructuring, even though a survey of enterprises outlines some specific problems[60]. In particular, foreign consultants are not always aware of the domestic problems and this reflects on the results of the consultancy and training provided. Therefore, involving more domestic consultants might increase the effectiveness of EU support, with the benefit of fostering interactions between domestic industry and research, and upgrading the qualification of human resources in PACs.

2.3 Scientific human resources and mobility

Introduction

Abundant and mobile human resources for research are now regarded as essential to a high performance research system in Europe and are the foremost important factor in the RDI system.[61] This implies a need for a significant increase in the stock of researchers in Europe and above all in the CEECs[62], where the numbers of active researchers declined significantly in the transition years. In some views this was a serious loss, in others a necessary shaking out. The most important challenge now is to motivate young people to enter research as a career and then to make it attractive to stay in research.

First, talented people will only enter research careers in adequate numbers if there are sufficient opportunities to train and an attractive environment in which to work as a researcher (i.e. good research infrastructures, centres of excellence, the possibility for research autonomy, flexible and performance related career paths and good levels of remuneration). Attracting young people is important because many researchers are leaving for other occupations (brain loss) and because the labour pool of researchers is ageing. At the same time, the market economy and changing practices and technologies require new skills from the researchers (e.g. management and marketing skills, retraining with new techniques, broader scope) which calls for changes in the system of training. The fundamental requirements are investment in research facilities and merit based research careers.

Second, the only sustainable solution to international brain drain (the downside of mobility) is the creation of high quality research opportunities in the candidate countries.[63] Actually, the integration of the R&D and innovation system of PACs into

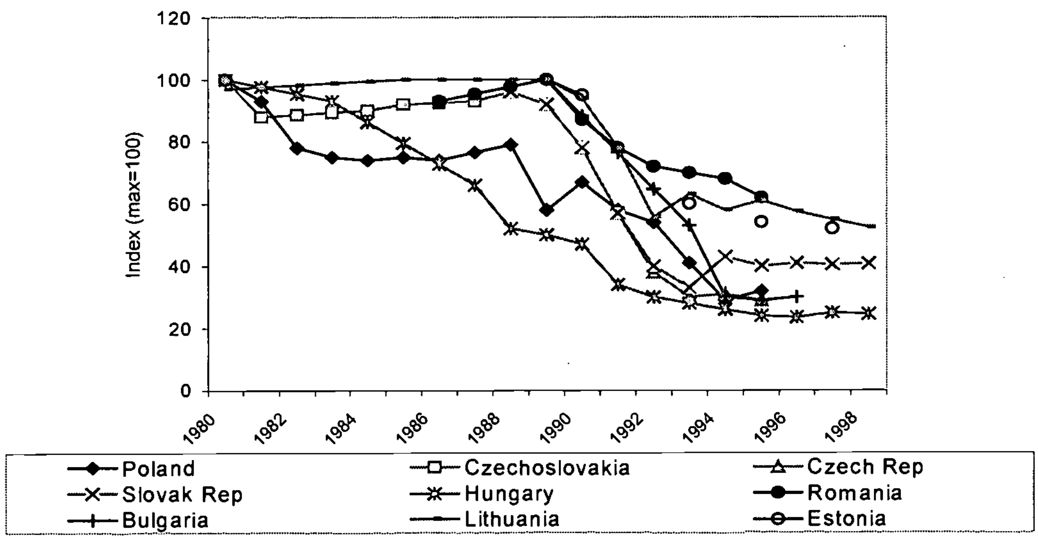
[59] EU Fifth Framework Programme, Tempus, Socrates, Leonardo, Phare, etc.
[60] Romijn (1998)
[61] COM (2000) 6 (18 January 2000), Towards a European research area
[62] European Commission DG Research (1999)
[63] See Casey et al. (2001)

the European Research Area has probably been facilitated through the participation of scientists in the community programmes and the national programmes for academic exchange of the EU members. This international exchange is widely seen as an important precondition for increasing the qualification of professors, researchers and students, for development of European research standards in PACs and wide European scientific integration.

Preserving and building of new assets

It is widely known that, the research capacity that existed under the former regime went into particularly rapid decline during the early 1990s. There was also a substantial outflow of scientists from technological activity in virtually all of these countries, and this did not appear to stabilise until the mid 1990s (Figure 6). On closer inspection, however, the loss of R&D personnel mainly affected industrial research rather than higher education (Figure 7)[64]. Indeed in some countries such as Czech Republic university teaching staff actually rose by 16% during the time of the shakeouts in industrial research (1990-93). The overall staff cuts indicate a substantial shaking out of an industrial research system poorly adapted to modernisation and not internationally competitive.

Figure 6: The decline of R&D personnel in the CEECs



Source: Adapted from Figures 7 and 8 in Meske (1998), updated

Incontrovertibly, however, the result was an absolute reduction in scientific human resources. First, there was a loss of qualified people out of the system. A number of the more mobile and talented researchers have been "brain drained"[65]. Many researchers have left the scientific labour force altogether and are now "under-employing" their skills in jobs which perhaps offer greater security and better pay, if

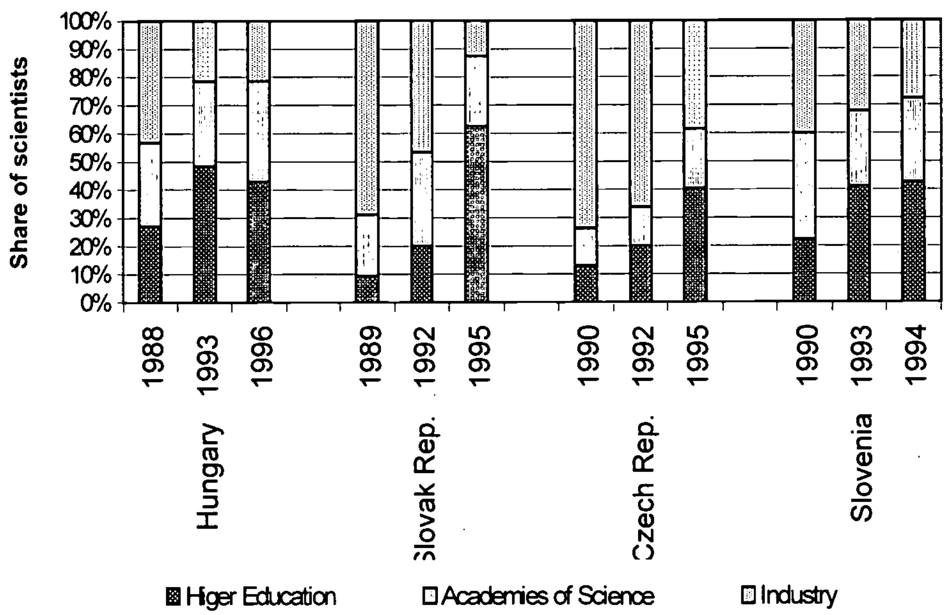
[64] The data in Figure 7 are not fully comparable because of changes and differences in the definitions used. However, the general pattern is clear and is repeated in the other countries that are not included here, notably Poland.

[65] It is hard to estimate the size of the problem. For example, during the period of transition in the Czech Republic the period of transformation, the number of university staff leaving for long-term stays abroad grew to a level of around 10% (with participation in short-term stays up to six months is much higher). Although this is significant previous fears of a massive brain drain in the Czech research sector did not materialise.

not the same intellectual challenge – i.e. 'brain loss'. Second, there was a loss of a potential training ground and employment potential for scientifically qualified staff - the new private firms tend to buy their technologies from the West rather than to locate R&D in the PACs. A lack of economic stability as it affects demand for S&T staff will tend to encourage researchers to pursue their careers abroad.

Presently, the main concern is focused on people leaving R&D for other economic sectors. However, for the whole society this brain-loss could be considered as a positive trend towards increasing the quality standards of the companies and the administration and distribution of knowledge in other sectors. For example, a positive byproduct is that many researchers start their own technology-based companies and hence contribute to growth of innovation activities of industry.

Figure 7: The relative sector changes of scientists (CEEC)



Source: Adapted from Figures 11, 12, 13 and 17 in Meske (1998)

In terms of new inputs to the stocks of researchers, the poor conditions for state-of-the-art research (due to the outdated equipment) and the low level of salaries in the research sector discourage young people from choosing a career in R&D. Few students choose to study scientific subjects. The young generation in the Czech Republic, for example, is not interested enough in such fields as physics, chemistry and some technical sciences, while students have become interested to a greater extent in humanities and social sciences, which were suppressed under the communist regime[66]. The relatively low intake of young people contributes to a general ageing of the population of researchers.

In response, significant policy attention is now being paid in a number of countries to attracting young researchers, through targeted seminars, training and exchange programmes. Moreover, the more directly vocational subjects (business, economics

[66] Illnerova (2001)

engineering and other technical studies) do tend to be quite popular opening the opportunity for a more applied research orientation of the R&D system in the future and thus improving the current situation.

Also, the market economy sets new requirements for R&D management and hence different R&D workforce skills are needed. New challenges for the human resources in R&D are to develop management and marketing skills necessary in the competition for funding, as well as for co-operation with industry and the international scientific community. Researchers need to develop a much broader scope in order to be able to assess the societal and economic relevance of their research and to conform to new technological trends and industry standards. They also need more generic research skills and knowledge to be able to work on projects across traditional disciplinary boundaries, as well as communication skills facilitating their work in multidisciplinary teams.[67]

Outdated equipment in research laboratories and universities is another bottleneck to world-class research in CEECs. It has been very hard for most of the institutes to attract national and international funding for the renewal of equipment. At the same time the unique and expensive scientific equipment provided through international funding or within research programmes has been often inefficiently used.

As noted above, a critical requirement in the development of the knowledge infrastructure is the attraction of young people into research careers. One aspect is the targeted replacement and updating of the research equipment so that it is possible for researchers and university teachers to pursue a career in their home countries. Another is the connection of the research-training system within the 'e-Science' infrastructures that are emerging to link up to researchers not just in Europe but globally. Also, establishment of bridges between doctoral training and research careers will be necessary for people to take the risk of embarking on the long process of becoming a qualified scientist. International collaborative projects will certainly improve the attractiveness of such a route, but the attraction of a research career should be at home as well as abroad.

Mobility of researchers in enlarged European Union

The removal of obstacles to mobility is a priority that has been ratified in a series of European Council meetings (the European Council in Lisbon March 2000, Research Council June 2000) and the recent publication of Communication of the Commission "a mobility strategy for the European Research Area." This Communication was recently launched in a conference in Brussels "An Enlarged Europe for Researchers." The Communication makes the point that mobility is important because it:

- fosters collaboration
- facilitates the transfer of scientific knowledge
- helps raise scientific excellence of individual researchers and supports centres of excellence
- widens access to top class training and facilities
- increases the efficiency of research investments by pooling competencies, experience, the use of share facilities

[67] Costas Constantinou, Panel member

In the development of the policies in this area much attention has been given to removing obstacles to mobility. Barriers identified by the recent High Level Group include: insufficient funding, opportunities for fellowships; immigration controls; incompatibility between social security and tax systems; lack of internationalisation of recruitment procedures; low support for families of researchers; and little transparency on implications of different intellectual property right regimes. In terms of administrative barriers to mobility it should be noted that researchers from candidate countries have advantages over other workers in that they will have early free movement within the EU15 supported by agreements on social security, bilateral tax agreements and the portability of supplementary pensions.

Women typically face greater barriers to mobility and high risks to their careers from taking periods abroad. The issue of return from an international experience perhaps at post-doc level is also problematic in that very few national research career structures are set-up to allow people to move easily from one country to another. A crucial aspect of these plans to stimulate mobility is the introduction of stringent quality controls on mobility schemes. This is essential to permit researchers to be sure that their period abroad does not lead them into a dead-end street because the host research centre does not provide sufficient opportunities to publish, develop networks with the club of elite world class researchers or gain frontier experience. This will be important for young researchers from candidate countries.

Meanwhile, the Communication also makes explicit mention of the need to avoid brain drain from less developed regions and candidate countries. It proposes to do this by furthering the distribution of research excellence in the different regions of Europe including the less-favoured regions and in the candidate countries. This is certainly being furthered by the participation of Candidate country research teams in European Community Framework Programme projects and by connection to the 2.5 Gbit research grid (GEANT and TERENA of the National Research Education Network Association). Such infrastructures increase access to European level research facilities such as those in the EIRO forum [68]

In addition, there are plans to make provisions for the return and reintegration of researchers. Here again a precondition is that there should be high quality research teams and opportunities to undertake cutting edge research in the home country – otherwise there would be nothing to attract back the most talented researchers.

However, with the growth of the economies in most CEECs (except Bulgaria and Slovakia) there are expectations of decreasing emigration of researchers to third countries[69]. In a pan-European prospective the mobility of researchers can be considered as a positive trend leading to the exchange of experience and new ideas, international and regional collaboration and innovation transfer. At the same time the personal appreciation of different cultures and traditions can contribute to the process of European integration. It is therefore worth thinking about increasing the flows of researchers also from the West to the East, in particular of students and young researchers.

[68] EIRO forum is composed of CERN (particle physics), ESRF (synchrotron radiation), ILL (neutron source), EFDA (fusion), ESA (space), ESO (astronomy and astrophysics) and EMBL (microbiology)).
[69] European Commission DG Research (1999), p. 248

The opening up of the PACs academic systems, and the influx of foreign funding, is leading to a considerably greater integration of PACs into the international science base. This is indicated in the rise of co-publishing. Some countries (Hungary, Czech Republic and Bulgaria for example) are able to build on strong research traditions. Other countries, such as Romania had much less to build upon. Such international integration, of course, carries risks from potential brain drain and very great transformation pressures on existing staff and resources.

Transformation pressures relate in particular to the role of academic research and teaching as it divides between academies of sciences and universities. There is considerable uncertainty about the future architectural structure of the higher education/research nexus.

2.4 New environment for research and innovation

The innovation environment and the management of knowledge flows are of crucial importance for candidate countries. However, if government measures are to lead to a higher level of locally based technology development and transfer activity, they must address those factors which facilitate the emergence of a new research and innovation environment – macro-economic and regulatory conditions, the communication infrastructure, the level of education and skills, the degree of personnel mobility, labour relations and prevailing management practices.

Scientific human resources are essential to a high performance knowledge system and require particular attention. Individual researchers are at the centre of present trends for strengthening of research at universities or in centres of excellence, for building flexible research teams and establishing regional and international patterns of research collaboration. Moreover, the availability of knowledgeable individuals facilitates knowledge transfer and innovation and the fast acquisition and application of new technologies by enterprises. Generally, the mobility of researchers contributes to wide dissemination and use of knowledge and to the integration of research into the economy and society. Therefore, it is necessary to focus on scientific human resources in order to preserve and upgrade the existing research capacities. The most important challenge, however, is to motivate young people to enter research as a career and to create an attractive environment to keep them in research, as well as to foster high quality research performance.

The low level of technology transfer within PACs underlines the need for public support to industry at national and regional level. Although during the process of harmonisation of the national legislation with the 'acquis communautaire' a number of measures have been taken, aimed at support of innovation activities and SMEs, their practical implementation has not brought the expected results (often due to inefficient application or lack of resources). Therefore, a challenge for all PACs is, on the basis of real data for innovation performance and industrial demands, to establish a favourable environment for companies to invest in new technologies and product development. There is a need for coherent national policy in support of innovation and the introduction of various instruments for direct and indirect financial support, provision of venture capital and new tax initiatives (e.g. tax allowances, indirect and pay-roll taxation, etc.).

In the process of national policy formulation by the government, regional development dimensions as well as particular sectors and branches should be included, to determine where to invest and where are the research and national comparative advantages needed in order to develop own competencies and identity. An important step is to identify concrete short, middle and long-term strategies that are tied into realistic and effective funding mechanisms.

Although a range of new institutional structures are emerging in most of PACs (e.g. information centres, science and technology parks, and business incubators), there is still a need to consider possible measures to provide a full range of innovation support services. Small and medium sized companies will need assistance in accessing technological knowledge and managerial expertise, as well as in financing their own research and innovation.

The effective framework for the protection of intellectual property rights, in particular industrial property (e.g. trademarks, industrial design and inventions, etc.) might contribute also to business incentives to conduct domestic R&D activities and encourages the transfer of state-of-the-art technology into the economy and its diffusion inside the country. IPR protection, as well as the whole industrial environment, are important conditions for FDI and need to be seriously considered by creating a framework for promotion of research and innovation in PACs.

Looking at the demand-side, market-driven development of industry might be a crucial factor for the growth of innovation activities in candidate countries. In the process of privatisation, restructuring or pure survival in the market, companies are not in the position to think about investing in research and development. But, in the long run competition will drive enterprises to introduce new technologies, new products and services, to think about new work organisation and marketing strategies. The large local companies might build in-house research teams or even invest in branch research units. Co-operation with universities for training and contract research are the first steps towards wider integration of research and industry in process of knowledge sharing and exchange.

On the whole, governments need to play an integrating role in managing knowledge in the whole economy, making therefore the technology and innovation policy an integral part of the overall economic policy. The corporate governance on one side, and the legal and regulatory framework on the other, financial support mechanisms, assistance for innovative SMEs, protection of IPRs and last, but not least, attracting people to stay in research – are important factors for the take-up of technology transfer and innovation and for building a coherent knowledge system in candidate countries.

Chapter 3
Learning Capabilities

3.1 Training and skills mismatch

Introduction

The global trends towards knowledge economy are changing the workforce in terms of size and composition, as well as the knowledge and skills required for success. The competitiveness of companies appears increasingly dependent on the ability to develop, recruit and retain a technologically sophisticated workforce. However, there are concerns that the labour in PACs is not able to meet market demand for skilled and knowledgeable workers and that this gap is growing. Therefore, the specific needs for a digital workforce need to be addressed by the system of education and training focusing in particular on economic relevance and higher quality and the need for life-long learning.

Vocational qualifications and the high tech economy

A preliminary view of indicators such as literacy rates and vocational qualification levels gives the impression that the relatively high educational levels provide a good basis for this future development. In international comparisons in terms of 'skill stocks', the CEECs perform relatively well.[70] The proportion of the working age population with more than just basic education in such PACs is comparable with the medium level OECD countries such as Spain, Portugal, Greece, Korea or Mexico. However, whilst literacy levels and basic vocational qualification levels are relatively high, the proportion of the workforce with non-vocational tertiary qualifications is lower than in the EU (Table 7).

Table 7: Vocational qualifications of the workforce in Central Europe, 1997

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	EU
Third level education	8	14	12	13	15	19
Upper secondary	33	32	34	34	28	38
Vocational and below	59	54	54	53	57	42
Total	100	100	100	100	100	100

Note: From survey's taken during the second half of 1997 except for Poland and the EU, which was taken during 1996. One per cent of the EU sample gave no response.

Source: Knell (1998) based on various national labour-force surveys and the 1996 EU labour market survey.

But a recent EBRD survey[71] casts doubt on the value of this stock of vocational qualifications. The survey tests the opinion of foreign investors' on the quality of labour in transition economies and the main deficiencies of workers there (Table 8). In particular, workers in candidate countries generally lack flexibility of adaptation and need on average around 6 months to achieve the same level of productivity like in Western

[70] see World Bank, 1996, Available indicators only partially capture all the aspects of human resource formation. On-the-job training, the tacit aspect of human skills, learning by doing, quality of education and institutional context of human learning are not captured.
[71] EBRD, Transition report 2000

Europe. A similar critique can be mounted at lower levels of educational qualification. In that the apparently abundant supply of vocationally qualified workers is belied by the quality of the skills. "It seems that the educational systems and the experience of workers in the period before transition did not prepare them adequately for the requirements of the market economy."[72] Both sectors of supply of qualified labour therefore are facing demands for structural adaptation.

This is one of the reasons for investors to remain hesitant about using the most modern production processes in Eastern Europe. Moreover, while IT specialists and financial staff are at least available, there are difficulties in finding experienced managers.

Table 8: Main deficiencies of staff in CEECs compared to home country (as % responses)

	technical skills	IT skills	general flexibility/ adaptability
University graduates	40.58	13.04	46.38
Vocational education	20.99	32.10	46.91
Secondary education	28.75	23.75	47.50
Primary or less	32.79	13.11	54.10

Source: EBRD, 2000

There is a significant mismatch between supply and demand of skills in different areas. This is generating either unemployed or underemployed specialists on the one hand and a shortage of specialists on the other.

Reforming vocational training provision

The problem seems to be one of both **structure** and **content**. The very high relative shares of lower vocational enrolments in the PACs indicate a structural problem of early and rigid specialisation leading to insufficient capacity to adapt due to a lack of transferable skills. Adaptations such as a later entry and higher level entry and the provision of complementary business training have been important in improving some of these problems. More attention to transferable skills is also needed to stimulate dynamic and autonomous learning capabilities, higher emphasis on analytical ability, creative thinking and communication and co-operation skills. This is true also for some CEECs such as Romania and non-CEECs such as Cyprus, where emphasis has been on rote memorisation in order to pass landmark examinations and competitions.[73]

The requirements are also strong to meet new fundamental demands such as ICT education, entrepreneurial and business strategic skills and the retraining of government officials. As regards the use of ICT there are many issues to tackle including access to basic infrastructure, development and training of trainers appropriate pedagogic methods and the lack of development of instructional content.[74] Given the relative under resourcing of schools and colleges in most PACs on these counts, a stepwise approach to this is necessary. An example is the Bulgarian national educational strategy for ICT in which effort is consolidated along certain lines (basic information literacy for all,

[72] EBRD Transition Report 2000, p.113
[73] For Romania see Korka (1999) and for Cyprus see Constantinou (1999)
[74] See for the example of Hungary in Mosoni-Fried (1999)

professional applications and ICT specialists) and areas of education (e.g. concentrating on 9-10th grade and entry level vocational schooling).[75]

An underlying theme emerging from reports on the educational systems in PACs is that, whilst the higher educational system appears to be on a reform track (in terms of expansion of capacity and the graduate skills), the vocational system seems to drifting away from the requirements of modernised industry in respect of both initial and continuing training (i.e. reskilling of existing technicians and skilled labour). While enrolments in more theoretical secondary and tertiary education are surging ahead, vocational schools are losing their appeal.[76] For example, in Romania, vocational and apprenticeships have declined from nearly 29% of students in 1993 to 24% in 1998.[77] Similar data found in Hungary and Slovakia with declines in enrolments in vocational secondary schools from about 35% to 25% (1989 to 1996).[78] These trends raise the issue of schooling that will retain a vocational component while at the same time avoid the early specialisation that decreases flexibility[79].

This seems to be a deep-rooted problem running the spectrum from trainers, qualification systems, to attitudes and capacities of employees and teachers.[80] Given the scale of the continuing training requirement, it is of some concern that international comparisons in 10 OECD countries placed participation rates in Poland in last position with only about 15% of 25-64 year olds taking part in job related training in 1995.[81]

As regards on-the-job training, with the exception of a few leading firms, it is difficult for skilled workers to acquire and maintain up-to-date technical skills because there is generally a lack of advanced applications of new technologies by local firms and because the foreign firms tend not to situate highly advanced plants in the PACs. The reasons for this reluctance to invest in the state-of-the-art techniques in the PACs may reflect experience (or a prejudice) that skilled workers in these countries are inflexible and so unable to deliver the necessary productivity levels. Productivity level's for such workers are thought to be 20-25% lower than in the investor's home countries. Whilst around 40% of the investors responding to the EBRD survey claimed that inflexibility of workers is the main deficiency of workers relative to the parent company. These results are of course highly variable on a regional level, with the quality gaps being negatively related to progress achieved in transition.[82]

However, other issues remain. One issue is certainly the restricted levels of funding available to this sector. On the one side government loans might be financed through incremental taxation on trainees once their incomes rise. Although institutional weakness and the relatively high risk of unemployment may make such schemes unworkable. Government training vouchers were also suggested by the EBRD. However, such schemes will probably only work if there are reforms in the mode of provision of vocational training. Perhaps by creating social partnership or 'dual training' type

[75] Bulgarian Ministry of Education and Science (1998)
[76] This may not be completely generalised – for example in Slovenia it is claimed that "In general vocational education is well developed and connected to the employment needs of regions and fields" Umek (1999) p.133. He further states (p.140) that these are mostly private with little state support.
[77] Korka (1999)
[78] Unicef (1998), p.23
[79] Costas Costantinou, Panel member
[80] See for example Kaps et al. (1999), while Kwiatkoski (1999) characterises Polish teachers as "numerous, underpaid, conservative and inefficient" p.88
[81] OECD, 1998, quoted in Kwiatkoski (1999)
[82] The adaptability issue was much more often cited as the largest obstacle to business development (40% of respondents) compared to Romania (27%), where other problems such as a lack of incentives to investment were paramount.

apprenticeship models along German lines might increase the industrial relevance and employability of trainees. Also on the agenda are plans to broaden the range of skills ('polyqualification') acquired to give trainees flexibility in the future, given high rates of technological and economic change. Such innovations in qualification systems of course are usually underpinned by co-ordinated attempts to increase the recognition of the certificates at a national or international level. Another issue is the failure of universities in most PACs to form the necessary partnerships to meet the needs for further professional training and lifelong learning.[83]

The structural mismatches between labour market supply and demand cannot be tackled by the education and training system alone. On-the-job training and learning by doing are crucial to resolving them as many lower level vocational qualifications and practical acquired skills become obsolete. This is one of the crucial obstacles to restructuring in the CEECs, which is especially worrying in view of signs that the traditional system of enterprise-based training in Central and Eastern Europe is collapsing[84]. All in all, this points to the fact that training during the business process (on-the-job training and learning by doing) is essential for massive restructuring to take place. Its focus should be the creation of transferable skills. However, this is unlikely to be done by companies whose incentives are to support development of more specialised skills. Obviously, this is a case of market failure where there is considerable scope for various types of joint public-private initiatives.

3.2 Towards world class higher education and training

Introduction

Enhancing the attractiveness and competitiveness of higher education in Europe is one of the objectives of the commitment of the European ministers for building European Higher Education Area. The Bologna Process[85] sets new requirements for higher education also in candidate countries. The introduction of greater flexibility in learning and qualification processes could provide transferable skills and facilitate student access to the labour market. The international recognition of the quality of teaching and research in higher education is an important feature for the development of colleges and universities. At the same time it fosters international mobility and gives the citizens the opportunity of using their qualifications, competencies and skills throughout Europe. The establishment of a system of credits, the close co-operation for setting up of coherent quality assurance and accreditation/ certification mechanisms are cornerstones of a world-class higher education system.

Higher education trends

In Central and Eastern Europe the Soviet division of labour between universities and very specialised higher education schools (in charge of teaching) and academies (in charge of research) prevailed up to 1990. Many countries have by now re-integrated research into the universities and are re-defining the tasks of the academies and their

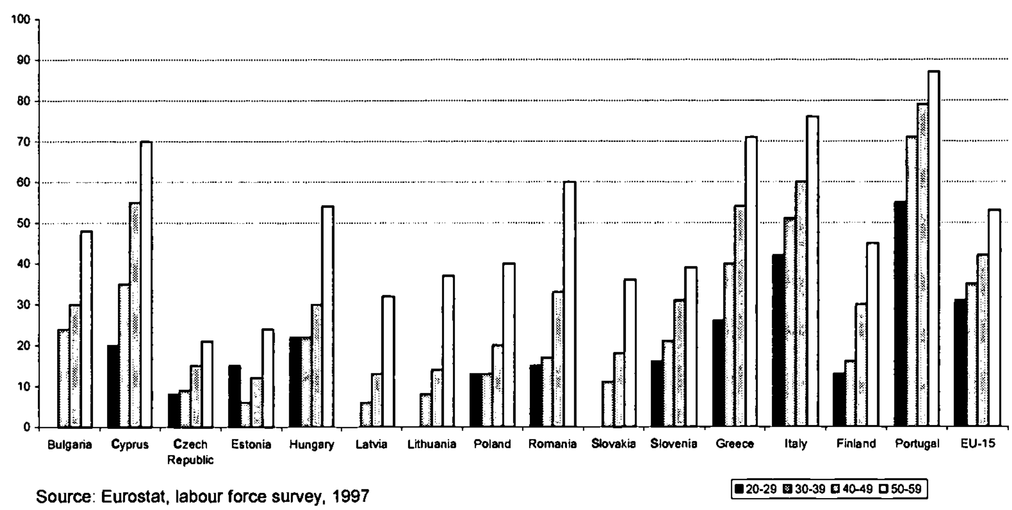
[83] Costas Constantinou, Panel member
[84] Boeri and Keese, 1992
[85] http://www.unige.ch/cre/activities/Bologna%20Forum/Bologne1999/bologna%20declaration.htm

relationship to the universities, which are re-emerging as centres of higher learning and research.[86]

During the transition period higher education institutes in PACs were affected by the deep reforms. Higher education institutions established new relations with state organs, industry and Europe-wide co-operation. Today university autonomy, new democratic principles, the elimination of restrictions to academic freedom, and new academic curricula in tune with the economic trends and changing student demands all characterise the emerging higher education system.

Whether the new systems are unitary[87] or binary[88] there is an increased recognition of the needs of students and employers. Many new programmes have emerged that are professionally oriented and focus on the industrial needs for specific management (innovation management, quality management) and multidisciplinary skills. The growing university-industry collaboration in developing curriculum, new programmes, PhD projects influences further the economic relevance of the higher education in PACs and the inflow of high-skilled specialists to industry and research.

Figure 8: People which do not have an upper secondary qualification (in % by age group)



Source: Eurostat, labour force survey, 1997

In terms of the future, rising enrolment rates indicates higher flows of qualified entrants to the labour market. In the 18-24 age group Slovenia, Baltic countries and Bulgaria show participation rates in tertiary education that are similar to the average rate for the EU (23%). As elsewhere, increasing numbers of young people are studying beyond secondary level. The percentage of the population leaving school without a qualification at this level has been progressively decreasing and as a consequence the educational level of the population is rising (Figure 8).[89] The increasing student numbers observed in some CEECs is partly a result of the new private universities and partly due to high levels of

[86] Haug et al. (2001)

[87] Unitary systems exist in the Czech Republic, Romania, Slovakia. They are characterised by higher education institutions/ universities offering both general academic degrees and more professionally-oriented programmes.

[88] The binary systems are based on traditional university sector and distinct non-university institutions for higher education. In some candidate countries they are still in the development phase, with the new laws on higher education adopted in the 1990s providing for the possibility to set up non-university and private institutions. As for Malta, higher education is just changing from a unitary to a binary system., Haug et al. (2001)

[89] see Eurostat (2000b), pp. 3

youth unemployment causing many younger people to opt to stay on in education.[90] In Hungary and Poland, for example, unemployment affects approximately one quarter of the youth labour force who have left school.[91] So far, though, the student population in higher education (2% of population) is still relatively small compared to the EU average (3.2%), especially in countries that have substantial reforms to achieve such as Poland and Hungary.[92]

In terms of patterns of specialisation in higher education, there also appear to be relatively high proportions of student enrolment in the 'practical' disciplines of business and engineering. Tertiary studies in science and engineering have average annual growth rates two to three times those of most of the EU. Whilst, the historic lack of attention to the teaching of economic and business skills has created rapid growth in enrolments in social and administrative sciences, at least twice and up to as much as six times the growth rates in EU countries. For example, in the Czech Republic (Table 9) students have already changed their perception of university education, viewing it not only as a way of preparing for a vocational specialisation but mainly to benefit from a generally conceived educational system and to acquire transferable skills (analytical thinking, learning foreign languages, computer literacy). Indeed many students seem to be choosing studies that offer good earning potential. Thus a survey in Hungary found, that of 96 per cent of recent engineering graduates, that were seeking extra training, two thirds would prefer training in economics.[93]

Table 9: Czech Republic: number of accepted university students in the first year of initial study (master`s or bachelor`s degree) by type of faculty

Type of faculty	1989		1992		1994		1996	
Engineering and Technology	7,468	32.6%	7,110	25.3%	11,390	34.1%	11,323	29.3%
Natural Sciences	2,252	9.8%	2,961	10.5%	3,255	9.7%	4,417	11.4%
Medicine and Pharmacy	2,277	9.9%	1,663	5.9%	1,518	4.5%	1,963	5.1%
Humanities and Social Sciences	4,193	18.3%	7,469	26.7%	9,776	29.2%	11,495	29.8%
Agriculture and Forestry	1,431	6.2%	1,379	4.9%	1,768	5.3%	2,160	5.6%
Pedagogy	3,169	13.8%	4,400	15.7%	4,343	13.0%	5,164	13.4%
Others	2,154	9.4%	3,092	11.0%	1,394	4.2%	2,068	5.4%
Total	22,944		28,101		33,444		38,590	

Sources: Statistical Yearbook (Universities) of the Institute for Information in Education, Prague 1990-97

The recent expansion of participation in higher education, however, must raise questions as to the quality of the provision. The lack of indicators here prevents a clear picture. But, rising output has not seen a corresponding increase in the numbers of teachers. For example the recent growth in private universities in some countries, whilst needed in order to meet quantitative demand, may not be able to call upon sufficient top-level experts to provide the teaching.[94] These problems may be quite substantial, especially

[90] Umek (1999) suggests that the very high 90% of secondary school graduates going on to higher education in Slovenia may be related to a marked difference in job opportunities for two levels of education

[91] Eurostat (2000b), pp. 8

[92] Comparisons are indicative because of the difficulty of comparing different educational systems, especially as to what is included with tertiary education, and given changes in the statistical collection procedures.

[93] Mosoni-Fried (1999)

[94] See the Czech Republic case: Filacek et al (1999) where six new universities have opened since 1990

given the underlying (and still untackled) mismatches between the role of the old system of higher education and the demands it faces today[95].

In fact the academic staff is decreasing and ageing rapidly. In Lithuania, for example, it is expected that in 10 years more than 2/3 of the professors will be over 50 years and 1/2 of them even over 60 years old[96]. Indeed, many young people are put off a university career because it takes so long to establish themselves in the independent position of full professors. The observed shift in the interests of young people towards legal and management-oriented studies makes the issue for attracting them in university teaching and research more difficult.

Efforts to overcome this problem in Estonia have reached some results, whereas the rising average age of university staff has stopped. However, the slow increase in the number of doctoral degree holders is too low to permit the reproduction of the Estonian science and higher education. In order to ensure continuity of academic education and science, Estonia needs ca 80 new PhDs per year (following the corresponding ratio in Finland and Sweden, even 200). In 1991–1998, on average, 38 students including external students have completed doctoral courses at Estonian universities and 5–10 students abroad.[97]

While solving the problem of ageing professors and attracting young people in research and university carrier, which correspond to the present demands of the increased student population, PACs need to consider also the impact of the present demographic changes on the longer-term development of universities. A serious assessment of the demographic trends at national and regional level is needed to ensure sustainability of the higher education system in the longer run.

Another issue for universities is to develop cross-institute linkages to deliver courses. In fact, following recent growth higher education seems now to be in processes of consolidation, mergers or affiliation of smaller specialised institutions (Box 9).

Box 9: Structural changes in higher education

In *Estonia* the Tallinn Technical University and the University of Tartu have established nation-wide regional networks linking previous independent colleges and higher vocational schools to the university. These trends might have positive impact on fostering regional collaboration and increasing the image and the educational level of smaller institutions. The existence of branches of higher-educational establishments and the exchange of teaching personnel might contribute also to the availability of better educational opportunities at regional level and overcoming the financial barriers to many young people related to the change of their place of residence.

In the *Czech Republic* a strategy is being elaborated for the restructuring of the non-university institutions, as they are seen as being too numerous (around 170) and too small (in 1998/99 only 13 institutions had more than 400 students). The plan foresees that they will be merged, where possible, and will be expected to offer very diversified programmes ranging from one to three years in accordance with labour market needs.

(Sources: OECD, 2000a; Haug et al., 2001)

Concerns about quality of courses affect the value of the degrees obtained. Many PACs are moving towards a more flexible award structure consistent with Western models.

[95] see Dyker et al. (1999)
[96] Makariunas, 'Enlargement Futures' Project Steering Group meeting, January 2001
[97] Rein Kuttner, Panel Member

Some candidate countries will introduce an 'Anglo-American' degree structure with shorter first degrees and many post-graduate possibilities based on a two-tier system (Box 10). However, the degree titles vary considerably and often they do not by themselves give an explicit indication of the type and character of a specific qualification and there is still much work to do to make the course offerings more consistent.

Box 10: University programmes in PACs

In *Poland*, where the existing system still combines one-tier and two-tier programmes, the draft of the new higher education act concentrates on the two-tier model. In *Estonia* there is a move to standardise the duration of Bachelor programmes to three years and of Master programmes to two. In *Slovakia* a new higher education law will provide for an institutional diversification into universities (offering all three levels of degrees in a large variety of subjects), specialised higher education institutions on university level, but with a more limited range of disciplines, and professional higher education institutions offering Bachelor programmes relevant to the labour market. Slovakia is planning to introduce the 3-2-3 model as the standard structure. It should be noted, however, that some of the two-tier systems still contain one-tier Master programmes in specific fields, e.g. in Bulgaria, Poland and Slovakia.

(Source: Haug et al., 2001)

Accreditation and transferability of skills

The contemporary trends towards mobility of the labour force and the need of transferable skills face candidate countries with the challenge of building flexible and internationally consistent higher education and training. The new framework needs to create conditions for international compatibility and acceptance of the degrees and qualifications, as well to introduce greater flexibility in learning. The participation of PACs on equal footing in the European Higher Education Area requires some efforts to make their higher education more attractive for foreign students and to enhance its competitiveness. The international recognition of the quality of teaching in higher education is an important feature for the development of colleges and universities and could facilitate the academic exchange with universities in EU15 and other countries.

The efforts of PACs to establish a system for quality assurance in higher education are focused on the introduction of licensing procedures for teaching and accreditation/ certification mechanism. Most of PACs have an accreditation agency, sometimes with quality assurance functions. Some of them (such as Lithuania) have an evaluation agency with no accreditation functions. Countries without an agency yet include Poland and Slovenia.[98] Through the process of accreditation could be periodically evaluated the educational activities of institutions or specialised units of higher education, as well as study programmes. However, the independent judgement of the experts involved in the accreditation is especially dependent on the educational standards to be complied with. This calls for the harmonisation of national educational standards of PACs with the international ones in order to facilitate mutual acceptance of degrees and qualifications and to achieve international recognition of the education.

The establishment of a credit transfer systems, compatible with the European credit transfer system (ECTS) is another challenge for PACs[99]. The participation in international academic exchange programmes, e.g. Socrates/Erasmus, requires a stricter application of ECTS-principles. On the other hand, the adoption of a credit

[98] CRE Project (2001)
[99] At present, only Cyprus and Malta work with ECTS and ECTS-compatible systems.

system and the changes of the degree structure could be considered as important factors facilitating mobility and employability within the countries and in Europe, and are cornerstones on the way towards international integration of higher education and training in PACs.

Challenges for the future of higher education and training in PACs are the development of new modes of delivery including open-distance learning and greatly expanded use of information technology throughout the higher education system. Furthermore, there is a need for seeking of the problem of re-training current professors and developing the next generation of faculty and researchers and for strengthened doctoral programmes and international affiliations[100].

3.3 The right to education and the danger of 'dual society'

Introduction

An education system providing access for all citizens can play an important role for building human capital and for rebuilding the economy and improving its competitiveness in the long run. The high skills and learning capability acquired during the educational process have also a potential impact on strengthening democracy and social cohesion and promoting the participation of all citizens in the democratic processes of building a knowledge society. Besides their economic and societal impact, the equitable education contributes to the higher quality of life of all citizens improving his/her skills and thus the opportunities for a better life.

Assessing the positive impact of higher education and training on the economy and society as a whole, all the implications of the educational gaps on personal life and behaviour, there is an obvious need for provision of equal opportunities of every individual to acquire higher skills and knowledge. Therefore, high on the policy agenda of every government is the goal of improved access to high quality education and the provision of skills promoting lifelong self-development and social participation.

Present educational gaps

During the communist time the children in CEECs had wide access to basic education, equal for all genders and societal groups. High literacy rates were achieved in most countries. In the transition period, however, CEECs had to balance the preservation of the public education achievements of the past with the need to reform the system and introduce new management, new educational curricula and materials. Educational systems faced the challenges of providing education needed for the digital age at a time of massive economic and social changes.

The economic decline during the transition caused a serious drop of the educational budgets. Most of CEECs were able to maintain the share of GDP available for basic education and thus the respective enrolment rates (Table 10). However, due to the large declines in economic output and government revenues, the state support for education has been seriously reduced in real terms. For example, in 1996 the real expenditures on education, compared to the 1990 level, have fallen in Hungary to 78%, in Slovakia –

[100] OECD (2000a)

69%, Latvia – 55% and in Bulgaria – 25%.[101] The insufficient financial resources for education have led to lower wages of teachers, bad preservation of educational infrastructure and cancelling the provision of additional services in the educational institutions (e.g. full-day supervision, meals, health care, etc.). With its low status and relatively low pay, it is not surprising that recruitment is falling in the teaching profession so that it is not only ageing (in some cases) and has become highly-feminised.[102]

Table 10: Basic school enrolment ratio (in %) 7/8 to 14/15 years old

	1991	1992	1993	1994	1995	1996	1997	1998
Bulgaria	97.3	95.1	94.0	94.3	93.7	93.6	94.0	94.3
Czech Republic	98.7	99.2	99.1	99.5	99.4	99.2	99.1	97.6
Estonia	93.8	91.1	91.4	91.5	92.3	92.6	93.5	95.0
Hungary	99.2	99.2	99.1	99.1	99.1	99.2	99.2	99.2
Latvia	94.5	91.1	89.1	88.6	89.1	90.7	91.3	90.9
Lithuania	92.0	92.5	91.6	92.1	93.2	93.3	95.1	96.1
Poland	97.3	97.1	97.2	97.1	97.2	97.4	98.0	98.1
Romania	89.4	89.6	90.3	91.4	92.6	93.9	95.0	97.0
Slovakia	96.5	95.7	94.9	94.4	94.3	93.4	na	93.9
Slovenia	96.8	97.6	97.8	96.7	97.3	99.8	99.8	98.2
Turkey[1]	89.03	88.69	85.48	83.08	90.07	90.33	90.74	82.21

Source: EBRD Transition Report 2000 (1) Statistical yearbook of Turkey 1999

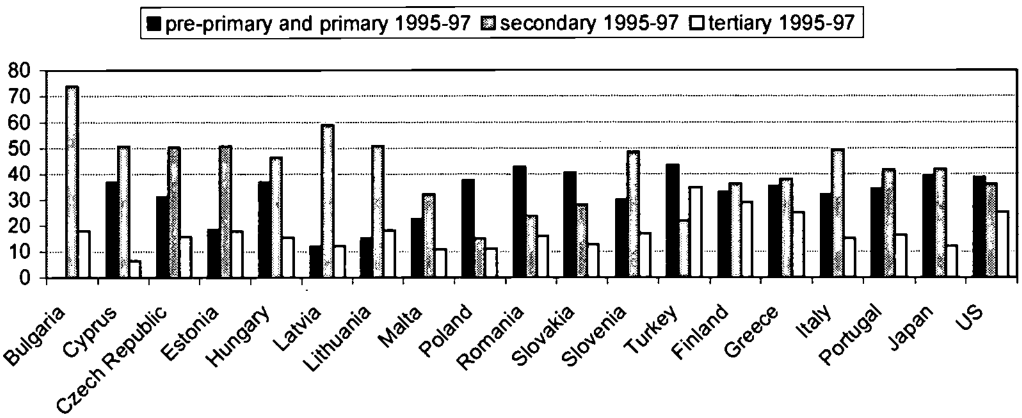
CEECs have introduced decentralisation of educational finance and responsibilities. The unequal distribution of financial resources to local authorities has widened regional disparities in the provision of education and training[103]. Besides the falling educational quality and growing prices for learning materials, a number of schools have been closed in rural areas, requiring the children to travel every day to the closest town. At the same time, due to high regional unemployment and falling wages, families in small towns and rural areas have been not able to meet the increased expenses for the education of their children. Thus, the kids in rural areas, where the education is really needed to break an intergenerational cycle of unemployment and deprivation due to missing skills, have limited opportunities to obtain better education and skills and improve their life.

The overall decline of education budgets on the one hand, and the emergence of private educational institutions and additional paid classes, on the other, are encouraging new elite education streams. In particular, higher educational performing secondary schools are able to attract additional finance from private companies and non-governmental organisations. This further widens the educational divide and the opportunities for obtaining up-to-date education using new educational tools and communication technologies. This elite stream probably explains the continuation of high mathematics and science scores in international tests. According to the results of international studies[104], the children in 7th and 8th grade in the Czech Republic, Slovakia, Slovenia, Bulgaria and Hungary have better results than in Germany, the U.S. and other OECD countries. These might be a result not only of the good educational traditions in these areas, but also of the present emphasis on secondary education (Figure 9). Obviously, many candidate countries (Bulgaria, Cyprus, Czech Republic, Baltic countries, Slovenia, Malta) streamline

[101] UNESCO (2000a)
[102] UNICEF (1998) p.29; see also UNDP (2000a)
[103] UNDP(2000b), p.72, World Bank Institute (2001)
[104] UNESCO (2000a)

more funds in secondary education, while others (Poland, Romania, Slovakia, Turkey) focus on primary education. The large size of the countries from the second group (except Slovakia), and the large number of population living in rural areas face the governments with more complex problems in providing equal education opportunities. In Turkey, the growing number of children accentuates the challenge.

Figure 9: Public educational expenditures (as % of all levels)



Source: Human development report 2001

Special attention requires the polarisation in education, e.g. the widening gap between regions, small/large towns and rural areas, social groups, genders and nationalities. Candidate countries are presently faced with grave problems such as early school leaving and youth employment, few upper-secondary graduates, declining of vocational training enrolments[105]. Some children have limited opportunities to continue their education due to the high costs for textbooks and learning materials. On the other hand, the lower level of acquired knowledge in basic school and the lack of means to pay for additional course results often in inability to pass the entry exams for upper-secondary and vocational schools, as well as for tertiary education. Thus, the admission to higher-level education and obtaining better skills is a function of the efficiency and quality of the previous educational level and might impose serious barriers for further personal development.

There is also great concern about children from disadvantaged groups[106]. Although a number of measures have been declared, drop-out rates are very high amongst children from ethnic minorities, in particular Romany children, children of refugees or those with physical and mental disability. Their integration and the provision of equal opportunities for raising the literacy level of the population are important in order to bridge the growing divide in the society.

Meanwhile assessments of the adult literacy level in some candidate countries point out that it is below European standards[107]. The dramatic changes following the wide introduction of new technologies increase the requirements for life-long learning. However, the educational system in PACs is oriented to young people and to some extent

[105] see European Training Foundation (2000)
[106] see UNDP (1999b), p.57, UNDP(1998), UNDP(1999c); OECD (2000b)
[107] UNESCO (2000b), UNDP(1998)

to students that have recently completed their primary or secondary education. The training and re-training of adults is considered to be a task of their employees and partly of the social system for unemployment support. Non-governmental organisations have started initiatives focused primarily in areas where the demand and potential for economic gain are greatest (business, law, foreign languages, etc.). However, the costs of attending such programmes are often prohibitive.[108]

Hopes for the future of the education and training in PACs give the approval of new educational strategies and plans aimed at meeting the objectives of education for all, paying particular attention on children in rural areas, children with special educational needs and adult education[109].

Box 11: Access to education in Baltic countries

All three Baltic States have made strong commitments to civil liberties and to narrowing the gaps in access and opportunity for all people within their countries. They recognise that fulfilling these commitments is an essential condition for modern democracies, for accession to the European Union, and for full participation in the global economy. In the OECD education policy reviews, the teams underscored the need for further progress on:

- Narrowing the disparities in quality and educational opportunity between urban and rural areas (including the need for public administration reform to address the problems of small municipalities that lack the capacity to sustain strong schools).
- Ensuring that special needs students are served, including addressing the health and economic needs of young children to ensure that they are ready to learn.
- Continuing to make progress on addressing the needs of language and ethnic minority populations to ensure that they can be full participants in the civic and economic life of the countries.
- Countering the strong tendencies toward elite secondary schools and a focus on university entrance with deliberate steps to ensure that *all students* – not only the most academically gifted and those with social and economic advantages – have access to quality education and the opportunity to gain essential knowledge and skills.

(Source: OECD, 2000a)

Vision for the future of education

The education is a key feature for the future of candidate countries. However, faced with the economic reforms and increasing social disparities their governments are missing resources to meet the educational challenges. If not addressed, the educational divide will constitute a time bomb leading to 'dual society' in the future.

The non-equal educational opportunities for minority groups and migrant workers and the discrimination between regions and sexes might have dangerous consequences on the whole society, decreasing the share of society with higher skills. The lower levels of education have very high social returns related to economic growth, social cohesion, health, crime. Better-educated people have higher requirements on products they use, and their quality of life. Their contribution to the economic growth could be two-fold: as high skilled workers, and with their higher demands on delivery of a big variety of goods and services, which stimulates on its own the innovation of industry. Better-educated individuals are more tolerant, less inclined to crime and violence, infringement of law and another's property. Higher cultural achievements, peaceful life and environmental protection are also dependent on the overall educational level of the population.

[108] OECD (2000a)
[109] see country reports on http://www2.unesco.org/wef/countryreports/home.html

The improvement of the quality of education and the access of all individuals are essential for candidate countries. The present dilemma of introduction of paid education at all educational levels or further decreasing the quality of education might further contribute to splitting of the society. The regular monitoring and assessment of the education trends and achievements are important tools for early warning on possible problems and timely introduction of corresponding measures.

Investments in education and training are essential for the well being of the population, the strengthening of democracy and economic growth. There is a clear need for higher spending of PACs in basic education of urban and rural population with reasonable average quality, and in provision of adults' qualification and training. Alongside, more flexibility of the educational system might facilitate the learning among youth, who are working part-time or who disadvantaged in continuing education because of the lower quality of the rural school. Higher educational achievements of children need also to be encouraged, e.g. through special grants and scholarships mechanism for most talented children.

Within the process of integration of candidate countries to the EU, an early recognition of the dangerous implications of education decline might be an incentive to find various tools to close the West/East divide, similar to the ones used in the closure of the North/South divide between EU member states. At present EU15 member states are afraid of receiving a large number of low-skilled migrant workers after the accession. The contribution of the EU to the improvement of educational level in PACs might have two important stabilising effects – to reduce the low-skilled population in candidate countries and to increase their attractiveness to foreign investors as good potential markets and places with skilled labour force.

Future Steps

Where next?

A report such as this can only scratch the surface of the wide issues of technology, knowledge and learning in the candidate countries. We have tried to signal some of the main areas of challenge and opportunity, these include:

- Science and Technology governance: to move away from rhetoric to reality, ensuring balance of supply and demand, openness, participation and quality
- Building of a coherent Knowledge system: based on wide integration and interaction of education, research and innovation and their efficient utilisation in overall catching-up process and building future excellence
- Mobility of researchers: turning mobility into an advantage for the integration of candidate countries research into a global science and economic system
- Human capital formation: to meet present and future needs, ensure sustainable (economic) development and build cohesive knowledge-based society

As the title suggests this conclusion does not attempt to synthesise the results of our work but to look forward to areas of future developments of our work and to draw out some lines to strengthen the prospective elements of our work.

Cross-cutting issues to develop

Given that the work of all Thematic panels of the 'Enlargement Futures' project in this first phase has been largely in parallel, there are areas of work that cut across this panel and the others and which could provide a focus for the future. For example:

- Making a clear link in S&T priority setting between excellence of research capacity and relevance to economic and societal goals requires direct comparison of industrial specialisation profiles and FDI from the Economic Transformation Panel's work.
- Concerns for environmentally sustainable development and conservation of natural resources are very important for defining research priorities, especially in issue driven research, given the high importance of agriculture and protection of the natural environment in some candidate countries.
- Health needs and social developments (demographic ageing, endemic illness) have implications for S&T priorities in certain candidate countries. Introducing a societal prospective component to S&T agenda setting to take account of such trends is a very important part of assessing whether the research priorities are relevant to domestic requirements.
- Economic transformation in the form of developments of the innovation capacity depends upon a sectoral and regional level assessment of SME capacity for innovation and need for venture capital.
- Strategies and policies on intellectual policy are another issue relating to economic transformation that could be further explored. For example, issues to explore include the role of IPRs as an incentive to industrially relevant research or IPR issues in setting up university-industry spin-off and partnerships.

- Policies on learning and skills and the development of knowledge society issues have particular relevance for rural areas that face extreme problems of under-employment and unemployment.
- A generic problem, which affects panels' results, is the lack of comprehensive, reliable and consistent data on all PACs. Moreover, the different pathways these countries followed, the different economic situations, culture and traditions and even the different size, present a big challenge of any common treatment and make it very difficult to draw general conclusions or even group the countries.

Science and society: a key issue to develop

Although this phase of the project is now approaching completion, it has become clear that several key issues will have to be developed in further rounds of the project. These issues centre mainly around 'science and society' or more broadly the development of the societal component of a knowledge-based economy. As a preliminary mapping of these issues we can identify some major axes of development that could orientate future work. These fall under the headings of societal values and ethical issues relating to the development of new technologies, for example:

- Access – opening the opportunities of the knowledge/ learning society to the widest possible number of people
- Equality/ equity – especially concerning the role of women in research
- Governance issues – moving towards greater transparency in priority setting – finding appropriate institutional models
- Democracy – raising participation and motivation of people to take part in S&T decisions and development
- Ethical issues in the conduct of research and development and in the application and marketing of new technologies

Access to the Knowledge society: although we have considered in some depth the development of the S&T base we so far have not adequately addressed the wider societal implications of the emerging knowledge society/ information society. The on-going socio-economic transformation is based on 3 interrelated processes of increasing informatisation, changing communication and interdependence structures, and changing the processes of knowledge creation and utilisation. Research domains include what the ongoing transformation is about and what areas of research will gain in importance as for impacts on everyday life, systems of production and systems of opinion formation and new technologies production.[110] The recent efforts to extend the 'e-Europe' action plan towards candidate countries indicate a commitment to achieve a wider development of the Information Society Technologies.[111] The main lines are: working towards a cheaper, faster, secure Internet; investment in people and skills (including young people) and developing the use of Internet applications (e-commerce, e-government, e-health, etc.).[112]

Equality & equity: recently there have been significant efforts to evaluate the role and status of women in research.[113] The general picture is that despite of women at undergraduate level there are very few women in the higher echelons of science and research, even in disciplines such as biology where women take a major share of the

[110] See Tuomi (2001)
[111] http://europa.eu.int/information_society/eeurope/news_library/documents/index_en.htm
[112] See Gourova et al (2001)
[113] ETAN Expert Working Group on Women and Science (2000) Science policies in the EU: Promoting Excellence through mainstreaming gender equality, CEC, Luxembourg.

doctorates. This represents a serious under usage of trained and talented people. Some candidate countries figure in the very highest ranks of female participation up to graduate level (e.g. Bulgaria and Estonia). It is interesting to note that countries in which the status and wages of academics tends to be lower can sometimes have relatively high levels of women at full professor level (e.g. 17% in Portugal versus 14% in France, 8.5% in the UK and 6% in Germany). The ETAN[114] Strata report suggests (using the example of the high rates of women professors in Portugal) that bright male scientists were brain-drained or preferred better paid careers in industry. The only data offered for candidate countries indicates that these effects might be echoed in candidate countries. For example Turkey has a very high rate of women professors (22%) and Poland shows very steep rises in appointments of women to professorial positions: 9.4% in 1977 rising to 22% in 1996. However, further data collection would be needed to confirm this hypothesis. If true there is a basis, as in the Portuguese case, for targeted development of research infrastructures, group leader grants and fellowships to actually allow candidate countries to lead the way towards gender equal science system.

Governance: as we argued above the emergence of substantial foresight activities in several candidate countries indicates that a more open system of S&T priority setting seems to be on the way. However, governance structures remain fragmented (many overlapping departmental responsibilities and also gaps of coverage). There are also concerns about the extent to which the different levels of governance actually connect. Transition and accession puts a double pressure on the development of governance systems because the process of institution building is not yet complete at a national level and yet is being overlaid by the requirements to establish further levels of governance for the EU.

Democracy: for the CEECs, science was in communist times often directed towards the support of the political regime. With transition, this role has changed to the more normal scientific ethic, i.e. a deliberately apolitical stance. However, attitudes and behaviours are often slow to change. Thus particular efforts are needed to win back public trust confidence in the Science and Technology institutions and 'expertise'. For many candidate countries this lies on top of a more general need to find ways to involve the public in the rapidly advancing scientific knowledge and the complexity and interdependence of contemporary societies, economies and cultures (see Commission White Paper on Governance-July 2001). Such actions call for participatory mechanisms such as citizen juries and people's panels in technology foresight as well as joint meetings to allow exchanges of views from different countries on topics of European relevance (e.g. biotechnology applications).

Ethical concerns: "To facilitate collective decisions it is necessary to first clarify which considerations we consider most important"[115]. Developments in applications of new technologies, particularly in the sphere of Bio and Info technologies raise fundamental new questions on what do we want of these technologies and what are the consequences of our choices. Attention has been mainly focused on whether these technologies are good business, other focus on whether their use is right or wrong -does it add something good to our lives? Values, moral and ethics are at the foundation for public attitudes in particular with regard to genetic engineering.

[114] quoted above
[115] Pia Gjellerup (1999)

In contrast to the idea that **ethics** is a preserve solely of private preference **the use of biotechnology and genetic engineering is actually a question of political decision and choice.** Moreover choices such as which genetic engineering techniques are acceptable cannot be made by each country in isolation. Behind the choices lie attitudes and values. Debate on ethical aspects of relevant emerging technologies cannot be conducted in isolation in each individual country: initiatives should be joint. Candidate countries find themselves between pressures to operate very open research ethics regimes in order to attract multinational investment and on the other hand to help consolidate a European position on such issues.

Prospectives

In developing this report we were confronted with the fact that assessing the current situation in the candidate countries is itself rather difficult to assess due to the lack of access to fully reliable and comprehensive data. If this report has any measure of success it will be in capturing current challenges for the future rather than in providing a full prospective scoping of the 2010 time horizon.

However, the panel activity did make an attempt to put together some views on what are the major challenges and targets for pre-accession countries on the 2010 time scale. These tended to fall into two categories: **where might we be** and **where might we try to be** in 2010.

The '**where might we be**' statements provide a possible starting point for the construction of scenarios. For example, there was considerable interest in different strategies on the development of S&T specialization profiles at regional and national levels. Three scenarios were offered:

- <u>Full integration</u>: all PACs are integrated into the global/EU S&T system and specialised in areas where they could offer excellence or have competitive advantage.
- <u>Regional co-operation:</u> countries and/ or regions consolidate into co-operative blocs in respect to S&T capacity, in some cases these blocs could transcend borders to create trans-national innovative regions or corridors.
- <u>Uneven and multi-speed progress:</u> big variations emerge with some PACs well integrated in the global/ EU research area and others struggling to find a profile.

Here the implication is that a search for complementarities at both domestic and international level is likely to yield a more even and overall stronger basis for the enlarged ERA. In particular, to develop this further it would be necessary to have reliable mapping of existing areas of strength and an associated assessment of the relevance of these areas of strength in the context of national needs. This mapping would be linked to strategies to <u>establish solid centres of excellence</u> (CoE) according <u>EU criteria/</u> <u>standards</u> and to ensure the <u>sustainable development</u> and survival of these centres (target 10 years). This would require systematic indicators on candidate country CoEs against other countries and against EU15 standards including relevant drivers (i.e. not just scientific publications and citations but linkages with industry and soft indicators such as societal relevance and impact).

The where '**might we try to be'** are more normative scenarious: they concerned attempts to set targets in order to focus development. Example included:

- Setting verifiable S&T targets, such as achieving the average EU R&D spending level by 2010.
- 'E-everything' strategies: that is by setting some targets for the levels of development of e-services by 2010 in order to trying to leapfrog economic growth.
- Establish a flexible research career – this would involve a multi-point plan with targets to increase the career flexibility of researchers to be mobile between academic/ public research & industrial/ private research; attractive wage and benefits packages; better research infrastructure; incentives to young stars (from home or abroad) into candidate country research systems.
- <u>Knowledge society targets – making life-long learning a reality:</u> The panel argued strongly for targeted efforts to develop new models of schooling, vocational education that allows flexibility and transferability of skills, the establishment of transferable credit and compatible accreditation systems; continued education for teachers; new pedagogics that are learner-centred rather than didactic or content driven.

These cases are simply examples stemming from the creativity of the panel. The challenge would be to set up targets that are realistic and verifiable so that progress can be measured. Also, as with most performance driven plans, checks are needed to make sure that the targets are acceptable and legitimate and that they move developments in a desirable direction. Targets should be chosen as incentives to develop not for their own sake. Finally, a solid indicator base would be needed to underpin these strategies, and evaluation of achievements.

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Annex II:
Background – Science and Technology priorities

Annex II-1: Foresight derived Science and Technology priority areas

Cross-cutting enabling areas of S&T

I. Information & Communication Technologies

The main emerging S&T opportunities relate to the take-off of developments in the areas of ubiquitous computing & communications and ambient intelligence, and the need to develop intelligent user interfaces. The key trend breaks in the coming years relate to:

- Miniaturisation and the slowing down of Moore's law
- Massive demand for bandwidth
- Huge leaps in system and device complexity and intelligence
- A move towards mass customisation of ICTs

1. **Enabling ICTs for Knowledge Systems**, core ICT components & devices and industry specific applications/ platforms/ content; Fixed and mobile access networks and devices, Software engineering, methods and products;
2. **Ubiquitous Computing, Ubiquitous Communications & User-Friendly Interfaces** Ambient power sources; Miniaturisation; Sensors, micro-systems, embedded systems; Complex networks, software, functionalities, behaviour; Dependability, fault tolerance, graceful service decline; Computing and networking architectures; Cognitive and human systems models (Artificial intelligence) and understanding of the cognitive and social effects of the wireless society. Design and development of augmented objects

II. Gene Science and Technologies

Transition to the post-sequencing genomics era will see the development and implementation of new therapies, diagnostic tools and improved health-management strategies. The growing knowledge on the function of human genes and the role of these genes in maintaining health, causing diseases and determining the ageing process will have a high impact on human health, health care system structure and organisation, and pharmaceutical sector development. Advances in plant and animal genetics will modify agriculture and husbandry techniques, with new environmentally sound production processes. Major trend breaks:

- The completion of human genome sequencing will radically change the pharmaceutical paradigm, from "bio-chemistry" to "pharmaco-genetics".
- Developments in bio-informatics, broadly defined as computer-assisted data management tools, to store, access and analyse the data generated from investigation of biological phenomena.
- Production of plants and animals with pre-determined genetic characteristics (pest and drought resistant, with high feed conversion index, etc.)
-

3. **Post-genomics and bio-informatics** Proteomics; Transgenic animal models; pathogen genomes; Molecular epidemiology (especially about multifactoral diseases); Integrative biology; Pharmaco-genetics; data management tools; database and sequence analysis software development: research on IPR issues.

III. Nanoscience, Nano & Precision technologies

Nanoscience is a whole new emerging cross-disciplinary field drawing on physics, chemistry, medicine and biology, constituting in its own right a major new trend. It has a significant nano-scale 'materials science and engineering' component covering techniques and instrumentation for nanofabrication of ultrathin layers, manipulating material and building molecular architectures and lateral structures down to atomic scale, but also nano-phase materials with novel macroscopic properties. In terms of the array of potential nanotechnologies, important 'systems'-related challenges are also raised regarding integration and interconnection different nano-scale features to form functional components.

4. **Nano-scale fabrication and manipulation** Atomic scale layers & lateral structures (writing techniques, particle beams, self-organisation,..), ultra-precise surface figuring, analysis techniques of vertical/ horizontal structures, boundary layers & surfaces; Extreme Ultraviolet Lithography (affordable 11 nm or 13 nm x-ray sources, x-ray optics) printing, e-beam, self-assembly techniques.

5. **Novel Materials** nanomaterial & molecular architectures with novel macroscopic properties; nano-porous cavities and tubes for filtering, adsorption and storage of hydrogen, membranes for fuel cells, catalysts, nanodispersions for coating and hardening, layers for LCDs, antireflex surfaces, photovoltaics etc.

6. **Nanotechnologies & systems** integration & interconnection of different nano-scale features to form functional components, nano-scale devices & systems; complex combinations of mechanical, optical, electrical or chemical characteristics, of organic, inorganic or biological molecular structures; potential technologies in medicine, precision engineering, electronics, etc. - micro-invasive surgery & implants, artificial retinas, artificial antibodies, new lasers, millimetre wave components

IV. Advanced Materials

New materials are are fundamental enablers of almost all other enabling technology areas (especially ICTs and biotechnologies) and provide the basis for innovations in system technologies such as transport, energy, defence and aerospace. Particularly important trends are:

- The moves from passive structural and active functional materials to multifunctional materials and smart materials.
- The need for materials that lend themselves to sustainability requirements - longer service life, reusability, biodegradability.
- New materials processing techniques such as molecular design, nano-level self assembly, three dimensional printing.
- Radical changes in demands on materials in health care (e.g. biocompatibility, biomimetic materials for prosthetics), in construction, automobiles and aerospace (e.g. lighter and stronger materials for frames), in computing devices (VLSI, optical processing, quantum computing).
-

7. **Sustainable Materials** - recovery, re-use & recycling of complex materials, new renewable biological/ agricultural material feedstocks, fibres, lubricants, etc.; re-use of materials in renewing the built environment

8. **Functional Intelligent Materials** - new alloys, plastics, ceramics, composites, for health-care and industrial applications. more efficient and user-friendly with longer lifetimes. are more resistent to corrosion and chemical effects; programmable responses to specific stimuli. E.g. coded biomaterials with specific responses to specific biological environments.

V. Complexity & Complex Systems

Complex systems cover climate modelling, ecosystems under stress, interactions between social and natural systems, financial markets, complex product and production systems, transportation, energy and water supply, town and regional planning, engineering and software development. Typical features include large number of components and interactions, the multi-level/ multi-actor character of the phenomena, dynamic and non-linear behaviour, the time-criticality of actions, inherent uncertainty and unpredictability of their future evolution/transformation, and a huge volume of information. Critical challenges include:

- to bridge the gap between fundamental research solutions and applied areas where complex modelling is regarded as a key source of insight.
- Dealing with complexity arising out of an increasing interconnection between different systems. Examples include the much stronger coupling of the biological system to the eco-system via GMOs; the coupling of industry, energy and transport systems to climate; or the coupling of IT to the human brain and psychological system.
- the development of managerial and organisational approaches in relation to complex product and production systems in defence, aerospace and other sectors - through knowledge and soft technologies rather than modelling, chaos and complex software.
-

9. **Better understanding of complexity**: stability, control, reliability under changing circumstances, improving confidence in systems modelling; sensitivity analysis

10. **Generic tools and components** modelling & design, simulation, modular approaches for system design, and both specific and generic components for applications

11. **Computing infrastructure** massive computation power, hardware for simulation, infrastructure & platforms

12. **Data retrieval and system monitoring** tools for dealing with vast amounts of information retrieval and collection, intelligent retrieval, reducing interdependencies (the butterfly effect)

13. **Management of complex systems** Reliability and dependability; self-organising, self-repairing systems, risk management

VI. Fundamental Sciences (not developed)

VII. Knowledge Sciences and Technologies

This refers to instruments, routines and know-how for organisations to function effectively and for full participation of citizens. Efficient forms of organisation and knowledge management (creation, storage and retrieval), education and cultural technologies will have a critical role, enabling individuals and enterprises to cope with increasing levels of complexity. Knowledge sciences and technologies, involve a strong ICT dependence, but also include many other softer areas of S&T which are more tacit and contextual or human-factor dependent. Overall drivers affecting this area of technology include:

- mechanisms and regulations to assure quality and protection of knowledge and IPRs in order to underpin value creation.
- effective and widely useable soft (organisational and societal) technology.
- describe and understand mechanisms of knowledge formation, transfer and exploitation -data mining, data warehouse, 'thinking tools' based on dynamic and distributed databases.

Tools for new forms of business organisation, especially for SMEs.

14. Knowledge Management & Learning Organisations generic – Techniques related to business processes, organisational structures, training, etc. changing organisational boundaries - networks & distributed enterprises, B2B, B2C; Security, trust & confidence, and personalization; Technologically enhanced production, distribution and consumption. Methods of production and delivery. Techno-intelligent organisations. Models for learning. Business ecosystems.
15. Soft Technologies specific - Systems engineering, Distributed database management, Knowledge filtering and delivery; Datamining/ warehousing; Content creation and storage tools, Agent technologies, Sensors/ actuators, Integrated devices (eg product & service tagging) (Tacit) Knowledge creation, storage, retrieval and loss. Critical interfacing and consumption patterns. Customisation methods. Needs analysis. Marketing. Simulation
16. Education & Learning Technologies e-learning platforms (mobile and fixed access to info. and guidance) virtual teachers & mentors customised to specific learner needs; laboratory use (collaborative working groups); learning appliances (voice/ text/.., & behaviour recognition); understanding of the learning process (neuronal biosensors); organisational aspects (education at large); knowledge codification
17. Media Content & Cultural Technologies Language technologies; Media content development and human-machine interfaces; Tangible & intangible heritage technologies, both ICT-based and traditional
18. **Defence & Security Technologies** Space-based monitoring and observation; Encryption, data-mining and security management systems; Demining technology; Trust technology

VIII. Health Sciences and Technologies

The changing health demands of citizens are driven by rising expectations of standards of living and longevity, the ageing of the population and the hopes generated by highly publicised developments in biology and genetics (the research implications of which are covered below under gene technologies). Apart from genetics, major breakthroughs are expected in other areas such as tissue and organ engineering, surgery and the treatment of disease. In terms of health systems, rising costs and the logic of healthier lifestyles are leading to a switch in emphasis from reactive care to preventative care in health-related policies, extending the boundary to the fields of nutrition and education. New organisational principles and management tools will need to be developed to help maintain health systems working efficiently. Research should not only be aimed at developing new sophisticated treatments but also to achieve decreasing costs for methods to be widely applied.

- Application of informatics and telematics in clinics is still in its infancy.
- Changes in working conditions, lifestyles and food production systems will lead to the emergence of new diseases, and re-emergence of old ones in more virulent form.
-

19. Gerontology - Gerontechnology Ageing population - Assistive technologies & home-based nursing care technology; Patient friendly diagnostic devices for tele-monitoring of chronic illnesses prosthetics techniques
20. Preventative Health Care & Nutrition Changing lifestyles and food production systems, health education instruments and techniques; functional and therapeutic food; Organic farming; calibrated drug use & over-medication avoidance
21. Health-care Systems & Management Tools experimenting, demonstrating and benchmarking new practices and organisations in health services delivery corresponding to a prevention paradigm; standardisation in R&D of health care equipment; Organisational development - transnational Tele-medicine, Risk management, risk benefits. IPRs for pharmaceutical products; Information systems for health and health knowledge management EU-wide; Improved early warning systems for disease & epidemic control
22. e-Health ICTs for health care Bio-sensors and bio-electronics; Telemedicine and telediagnostic; Health data-storage and data-retrieval; health privacy and security; Imaging and computer assisted surgery; Medical decision support system.
23. Tissue Engineering Cellular biology stem-cells; pre-natal care & 'repair' 'spare parts' -, reuse, tissue engineering artificial organs; xeno-transplantation;
24. Biomedical Research: biomaterials; treatments for new and re-emerging diseases & for non-communicable diseases;
25. Health Risks Research Medicine & the food chain risk and precaution-related research - (BSE, GMOs, new treatments/ drugs/ therapies/, environmental causes)
26. Research on Risks to Privacy & Personal Integrity medical information risk and precaution-related research - (genetic information, hereditary diseases, medical records, cloning, insurance, ethical concerns)

IX. Technologies for a Sustainable Economy

Many sustainability and environmental issues require. Sustainable economy issues relating to production, distribution and consumption concerns also have many research implications for both direct R&D action and enabling and cross-cutting technologies (materials, ICTs and complexity). Three main lines stand out:

- Sustainable production and consumption, which refers to the need to develop new socio-technical systems within which innovation, growth and the satisfaction of material and immaterial needs go hand in hand with environmental sustainability.
- Management of natural resources and the environment in view of the impact of human development on natural systems. Management here refers to local (e.g. aquatic systems at catchment scale) as well as global systems such as the carbon cycle.
- Managing risks and mitigating adverse effects of technological progress. This requires a reduction of pollution together with a better understanding of its effects and higher safety levels for citizens and workers.
-

27. **Sustainable Energy Management and Supply Alternatives**: Safe efficient generation, transport, storage, transmission & utilisation; new infrastructures for electricity and fuels (incl. H_2), deregulated market logistics & demand management, sustainable energy services and utilities design, socio-economic and pre-normative research for policy & technology diffusion. New renewable fuels & sources of energy (solar, photovoltaic, wind, bio-energy, geothermal), the H_2 economy, embedded generation (micro-turbines, hybrids, fuel cells...), clean electricity (zero emission power plants, CO_2 capture & sequestration), next generation & evolutionary nuclear energy, nuclear waste management

28. **New infrastructure, logistical and control systems for sustainable transport:** high speed rail, transhipment and material management facilities, intermodality solutions, new transport forms designed to meet urban demands; Safety Techniques: integration of passive and active safety elements; traffic management, fleet management, engine control systems, convoy driving, passenger information systems, distributed dynamic databases and middleware, standards integration systems, GPS, tracking and tracing, safety techniques

29. **Sustainable Production & Consumption** Eco-efficiency demonstrators & experiments; technology enhanced service models that lead to dematerialisation; revalorisation-friendly product design; separation, reclamation and recovery techniques.

30. **Socio-Technical System Design for Sustainability**: systemic multi-factor design tools, organisational research on interfacing systems and structures, complex systems and modelling, research on economic incentives/pricing systems; new holistic forms of urban governance with citizen participation in decision-making

31. **Understand, Mitigate and Adapt to Climate Change and other Environmental Threats**: observation, assessment, and modelling of climate-change and eco-systems; environmental geographical information systems; remote sensing; integrated modelling of complex natural and anthropogenic systems; anticipation of climate-change effects, of natural & man-made disasters; controlling risks from chemicals and manipulated biological materials, eco-system & biodiversity preservation, experimental platforms for the management of ecosystems as natural resources, carbon sequestration, prevention of floods and other man-made and natural disasters, prospective analysis of socio-economic repercussions

X. Social Sciences in Support of Building Europe

Europe is confronted with a number of challenges that originate decisively from the socio-political realm. An enlarged EU needs new requirements for an efficient European multi-level governance structure and it needs to define its borders to the East and South, developing new concepts for the relationships with neighbouring countries. Demographic change and migration will be key challenges for both European and national policy. External relations are developing into an ever more important concern of the Union, in need of underpinning by research.

Europe will be then confronted in the future with a higher degree of diversity within its borders, culturally, politically, and economically. The diversity of values may in the future be complemented by growing intra-European mobility of people & the media.

Changes in the regional balance and cohesion of Europe, especially as they are affected by technological developments in ICTs will create a significant requirement for supporting socio-economic research. Together they raise important questions about the creation of an effective internal labour market in Europe.

Both social sciences and humanities have the potential to provide insights and thus support to policy in order to help build Europe, especially by working across disciplinary boundaries.

32. **Social science/humanities Implications of The EU Project** governance, citizenship & participation; cohesion Values research; extremism and crime; multi-cultural environment in Europe; principles of political systems

Annex II-2: S&T priorities in recent major prospective studies

Case 1: The Millennium Project

The Millennium Project is an on-going global participatory project of the American Council for the United Nations University involving over 550 futurists, scholars, business planners, and policy makers worldwide from 50 countries. In the following, we list a small sampling of some of the long-range S&T development issues which the Millennium Project has identified in the third year of its research.[116]

15 global challenges were analysed with explicit S&T implications in six of them. Here we just list some of the S&T prospects identified in relation to Challenge No. 14 *How can scientific and technological breakthroughs be accelerated to improve the human condition?*

The most significant characteristic of S&T developments identified is the extent to which progress is driven by cross disciplinary invention, research collaboration at a distance and rapid dissemination of information. These synergies have been accelerated by the global convergence of IT and communications technologies and continue to add NEW FRONTIERS of which the following five were highlighted:

- **Nanotechnology,** which is felt by many to hold the highest prospects for tomorrow's breakthroughs.
- **Biotechnology**, and particularly the aftermath of the mapping of human and plant genomes
- **Planetary astronomy** and **space research**, including search for other life forms and advanced research in biology and physics necessary for human space flight
- **Cognitive science**, including the development of a new psychology with insights into the nature of memory, self-consciousness, education, propaganda, disease,.. or decision science, bringing together understanding of how economics, risk-behaviour, and intuition combine to make decisions, and
- **Quantum computing** which is the development of computer technology based on the principles of quantum theory (i.e. that which explains the nature and behaviour of energy and matter on the quantum - atomic and subatomic - level). Development of a quantum computer would mark a leap forward in computing capability far greater than that from the abacus to a modern day supercomputer, with performance gains in the billion-fold realm and beyond.

Case 2: Global Trends 2015

The following list of future S&T related prospects was compiled from two different sources[117]. They are given in the form of predictive statements or trends as is often the case in scenario-based prospective studies. The statements are the views of experts, reflecting the techno-optimistic view that is typical of the scientific community. The coverage is not comprehensive but the sampling provided reflects some of the long-term 'scientific' frontiers suggested by the millennium project, plus a sampling of more issue-specific and technological trends.

[116] 1999 State of the Future: Challenges We Face at the Millennium, American Council for the United Nations (AC/UNU); J C Glenn and T J Gordon (2001) The Millennium Project: Challenges we face at the Millennium, *Technological Forecasting and Social Change* 66, pp. 129-312

[117] CIA (US) (December 2000), Global Trends 2015: A Dialog about the Future with non-government experts
Joseph Coates et. al. (1997), 2025 Scenarios of US and Global Society Reshaped by Science and Technology, Oakhill Press

- The integration of existing disciplines (nanotechnology, materials science, biotechnology, information technology) to form new ones, will give rise to a ***dramatic increase in innovation.***
- The ***time between discovery and application*** of scientific advances will continue to shorten.
- Many ***new IT-enables devices*** and services will emerge, diffuse rapidly, and decrease in cost in line with increase in demand. Miniaturisation will continue and the widespread integration of ICT devices into all sorts of products will see the emergence of so-called ***ubiquitous computing or embedded intelligence.*** The systems integration competence needed to exploit this trend is strong in Europe.
- Local-to-global internet access holds the prospect of ***universal wireless connectivity*** via hand-held devices and low-cost, low-altitude satellites.
- Chemicals produced in ***modern biotechnology based production*** plants (protein, polymer synthesis, bio-materials) will account for up to 20 % of all bulk chemicals in 2010.
- ***Medical applications of biotechnology*** will remain costly and available to wealthy segments of society.
- ***Materials technology*** will give rise to widely available products that are smart, multifunctional, environmentally compatible, more customisable. These will benefit manufacturing, logistics and personal lifestyles.
- ***Nanotechnology*** developments are likely to change the way almost everything - from vaccines, to car tyres to computers - is designed and made. The global economy will continue to become more ***energy efficient*** (traditional industries and transportation). The most dynamic growth areas in services and the knowledge fields are less energy intensive than the fields they replace.
- Fossil fuels will remain the ***dominant form of energy*** in spite of global warming concerns.
- Efficiency of ***solar cells*** will increase and genetic engineering will improve the prospects for the large-scale use of ***ethanol and hydrates.***
- ***Localised environmental problems*** such as high concentrations of pollutants in air, waterways and land will be managed and are unlikely to constitute a major constraint on economic growth and improving health standards.
- As transport demands grow, ***congestion costs*** (presently 2 % GDP) will continue to rise.

Case 3: Strategic Futures

The Performance and Innovation Unit of the UK Government's Cabinet Office recently published an analysis of 50 strategic futures studies completed in the last five years[118]. The report identifies dozens of trends which are set to shape the global future and that might be expected to affect UK policy over the coming decades. It grouped them thematically into the following six areas:

- Demographics
- Environmental Change
- Economics
- Science and Technology

[118] Strategic Futures Thinking: meta-analysis of published material on Drivers and Trends by S Davis, B Bolland, K Fisk and M Purvis (DERA) for the Performance and Innovation Unit, Cabinet Office, UK (DERA/CDA/S/152 (see http://www.cabinet-office.gov.uk/innovation/2000/strategic/Strategic_mainpage.shtml)

- National and International Governance
- Perceptions, Beliefs, Values and Attitudes

The report points out that the S&T driver holds a place of particular importance as the trends in this area will facilitate many trends and events in the other areas. It also points out that S&T along with demography are the most reliable drivers, as future developments can be often derived from current developments. Also, the fact that specific technological goals are being actively pursued makes some of the S&T trends unique.

A list of eleven trends and five wild cards were highlighted:

1. **Growth of IT/communications technology** (increased technological globalisation) and greater sophistication of computers.
2. Access to technology: Increasing access to IT and communications technology or creation of a **'knowledge gap'** as information access is restricted to those who can afford it.
3. Increasing reliance/use on **IT/communications technology** in business, medicine, industry and leisure.
4. Increasing use of **biotechnology** (including genetic engineering), particularly in medicine.
5. Increasing use of **artificial intelligence**.
6. Increasing use of **nano-technology** and miniaturised technologies.
7. Greater **reach** of the **media**.
8. Increasing reliance on **IT/communications technology in western military** (especially the US).
9. Greater use of **'asymmetric' military technologies** in developing countries and by paramilitary groups.
10. Use of vastly improved, more **robust and renewable materials**.
11. Continuing **US dominance** in the field of technological innovation.

The 'wild card' events listed were:

1. Viruses become immune to all known treatments
2. Self-aware machine intelligence
3. Sweeping medical breakthrough is perfected
4. Faster than light travel
5. Foetal sex selection becomes the norm

Case 4 Emerging Thematic Priorities

The final study we cite is a detailed expert-based secondary analysis of national foresight studies with the specific aim of distilling out from all the material the main topics and issues where research activities could or should be developed or continued across Europe.

First of all, we point out that in recent years in Europe, there has been a trend in research policy away from a *technology driven* to a *issue*[119]*-based* specification of objectives. This is revealed by the themes emphasised in recent national foresight studies, which are being used to inform research policy.

[119] Socio-economic issues and problems

The analysis of emerging S&T priorities from a European perspective based on national foresight studies resulted in the identification of ten priority areas[120] of S&T for Europe (see more details in Annex II-1):

Table A1: Priority S&T areas for Europe

cross-cutting enabling areas of S&T:	*demand-driven application areas of S&T*
1. Information and communication technologies	7. Knowledge science and technologies
2. Gene science and technologies	8. Health sciences and technologies
3. Nanoscience, nano- and precision technologies	9. Technologies for sustainability
4. Advanced materials	10. Social sciences in support of building Europe
5. Complexity and complex systems	
6. Fundamental sciences	

The identification of these areas was linked to important or emerging trend breaks presenting new challenges and opportunities.

- Trend breaks can be *bottom-up*, emanating from basic research and associated with new *enabling* areas of S&T (biogenomics) or new multidisciplinary fields (nanotech).
- Trend breaks can also arise from paradigm shifts in practice (knowledge & services dominated manufacturing, preventative health-care, precautionary research). These have much more to do with the ways in which S&T is *applied* and used in social and economic contexts.

Opportunities can present themselves in areas where leadership positions need to be maintained or built up. Such S&T priorities are strongly related to the creation of complementary competencies to maintain and develop technological leadership. For example, ubiquitous computing calls on a range of skills in hardware, software and communications fields and other fundamental enabling technology fields (e.g. complexity, advanced materials, nanotechnologies).

Overall, we see that the most prominent and recurring themes through the other studies, are also reflected in the Foresight analysis as one would expect. However, as we move on to consider the situation of S&T in the PACs, we must remember that the themes and issues listed above refers to the S&T frontiers, which in the context of any country, not just the PACs, is only part of the picture regarding S&T activities.

[120] IPTS Working Paper - Emerging Priority Research Themes for Europe, December 2000, http://priorities.jrc.es/

Annex III:
Science and Technology – framework and priorities in pre-accession countries

The full annex with country background information could be found on Enlargement Futures web site of IPTS http://www.jrc.es/enlargement/

Table A2: Selected indicators for R&D

Country	R&D expend. in mln. Euro[2]	R&D personnel[2]	Scientists & engineers in R&D per 1 000 000[1]		patent applications residents[1]		patent applications nonresidents[1]		GERD as % of GDP[2]			% of GERD financed by industry[2]		
	1998	1998	(1981-95)	(1987-97)	1995	1997	1995	1997	1995	1997	1998	1995	1997	1998
Bulgaria	65	19116	4240	1747	370	400	16953	27600	0.6	0.52	0.59	n.d.	22.9	18.7
Cyprus	19	564	n.d.	209	n.d.	n.d.	n.d.	n.d.	0.18	n.d.	0.23	83.6	n.d.	13.9
Czech Republic	630	23740	1285	1222	628	601	19382	29976	1.15	1.16	1.27	63.1	62.8	64.6
Estonia	29	4914	3296	2017	16	18	14751	26626	0.63	0.60	0.62	12.9	n.d.	19.6
Hungary	285	20315	1157	1099	1117	774	19770	29331	0.75	0.74	0.68	38.4	n.d.	38.4
Latvia	24	4437	1165	1049	210	163	16140	26860	0.52	0.43	0.45	20.5	23.8	21.0
Lithuania	55	12847	1278	2028	106	125	15882	26673	0.48	0.57	0.57	21.7	5.5	1.8
Poland	1022	84510	1083	1358	2598	2401	19491	30137	0.75	0.72	0.73	31.5	39.4	41.5
Romania	184	52454	1382	1387	1811	1709	16856	27346	0.68	0.58	0.50	30.1	81.4	76.7
Slovakia	156	16461	1922	1866	273	234	17659	27973	1.00	1.18	0.86	60.4	75.6	65.8
Slovenia	228	7985	1998	2251	318	285	16267	27162	1.71	1.42	1.48[5]	45.5	53.0	52.6[5]
Turkey	825[3]	:	209	291	206	233	1506	27985	0.38[3]	0.49[3]	0.50	30.8[3]	41.8[3]	41.8
EU-15	141200	861210	:	:	:	:	:	:	1.90	1.79	1.86	52.9	53.9	63.7
Finland	3335	26483	3675	2799	2533	4061	20192	105376	2.29	2.72	2.89	59.5[4]	62.9[4]	63.9
Greece	542	10972	774	773	452	53	44697	82390	0.81	0.82	0.90	n.d.	n.d.	20.2
Italy	10822	76056	1303	1318	1625	2574	63330	88836	1.00	0.99	1.02	41.7[4]	44.3[4]	43.9
Portugal	582	13607	599	1182	96	92	58605	106595	0.57	0.63	0.65	19.5[4]	21.1[4]	21.2
Japan	102555	604438	5667	4909	335061	351487	53896	66487	2.77	2.89	3.03	72.3[4]	73.4[4]	73.4
US	202172	964800	3732	3676	127476	125808	107964	110884	2.48	2.55	2.58	60.4[4]	64.3[4]	66.7

Source: 1 - World development indicators, 2 - Eurostat, 3 – State statistical Institute of Turkey 1999, 4 – OECD (1999), 5 – Statistical office of Slovenia, 2001

Table A3: Overview of innovation priorities and measures by Action Lines

	Ranking of innovation priorities															Number of innovation policy measures[121]													
Priority areas and sub-areas	**FI**	**GR**	**IT**	**PT**	**BU**	**CY**	**CZ**	**EE**	**HU**	**LI**	**LV**	**PO**	**RO**	**SV**	**SL**	**FI**	**GR**	**IT**	**PT**	**CY**	**CZ**	**EE**	**HU**	**LT**	**LV**	**PL**	**RO**	**SK**	**SL**
I. Fostering an Innovation Culture																													
I.1. Education and initial and further training	3	3	2	2	3	3	1	4	2	4	1	5	4	1	4		3	4	2	1		3	1	1			1		
I.2. Mobility of students, research workers and teachers	2	2	3	2	2	2	1	1	3	5	3	1	5	1	3		3	2	1	1			1	1			1		
I.3. Raising public awareness and involving those concerned	2	2	1	3	2	1	1	4	1	1	4	3	1	1	3		5	4	3			2							
I.4. Innovation and management of enterprises	1	2	1	3	1	3	1	2	3	3	4	4	2	1	1		3		4	3			1	1					
I.5. Public authorities	1	1	1	1	2	2	1	1	1	0	3	3	2	1	0			5	1			3							1
I.6. Promotion of clustering and co-operation for innovation	4	2	2	3	3	0	1	1	5	4	4	3	3	1	3			2	1	1		1	2	1					
II. Establishing a Framework conducive to Innovation																													
II.1. Competition	3	3	2	1	1	2	1	4	-	2	-	3	1	1	2					3									1
II.2. Protection of intellectual and industrial property	2	2	2	2	3	2	1	3	-	1	1	3	3	1	3	1	3	1	2	1				1					1
II.3. Administrative simplification	2	1	5	3	4	1	1	4	4	2	-	2	2	1	3			9	1			2	1	1					2
II.4. Legal and regulatory environment	1	3	1	1	3	2	1	4	2	3	-	3	3	1	3			1		1			1	2					
II.5. Financing of innovation	4	4	3	4	1	4	1	2	-	3	1	2	2	1	3	6	5	21	5	2	2							1	
II.6. Taxation	1	1	1	2	5	2	1	2	-	1	-	2	2	1	2				1					1					
III. Gearing Research to Innovation																													
III.1. Strategic vision of research and development	1	2	5	1	1	4	4	1	2	4	1	2	1	4	2		13	7		6				1	4				
III.2. Strengthening research carried out by companies	4	3	3	3	1	3	3	2	7	0	-	1	1	3	1	1	3	7	7		5	1	1		1			2	
III.3. Start-up of technology-based companies	3	3	2	3	2	4	4	1	1	1	6	1	3	4	2	2	4	4	3	2	1	2	2		1		1		
III.4. Intensified co-operation between research, universities and companies	4	2-	3	4	2	3	2	2	6	3	4	1	3	2	2	4	14	17	5	1	1	4	2	1		1	1		
III.5. Strengthening the ability of SMEs to absorb technologies and know-how	2	3	3	2	4	2	15	2	3	3	8	1	2	15	3	1	5	12	6	5	5			1	1		1	2	1

Source: European Commission DG Enterprises (2000)

[121] available in innovation database http://trendchart.cordis.lu/Datasheets/index.cfm?fuseaction=DatasheetOverview

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